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Colonial Museum and Geological Survey Department.

JAMES HECTOR, C.M.G., M.D., F.R.S., &c.,
DIRECTOR.

REPORTS

OF

GEOLOGICAL EXPLORATIONS

DURING 1881,

WITH MAPS AND SECTIONS.

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REPORT OF THE GEOLOGICAL SURVEY.

PROGRESS REPORT, 1881.

The duties devolving on me as Executive Commissioner for the Melbourne Exhibition have occupied a large share of my time, so that the extension of the survey by field work has chiefly been dependent on the exertions of my assistants, Messrs. Cox and McKay.

Special reports on various deposits of mineral ores have been obtained, and the geological mapping of the country has been extended over several large areas, which were either previously unexplored or only imperfectly surveyed.

Auckland District.

1. The district between Kaipara and Waitemata, about two hundred square miles, completes the general mapping of the peninsula north of Auckland, the first portion of which was published in 1868.

2. The Cape Rodney District and the Island of Kawau were re-examined, with a view to the revision of the classification of the outliers of the Tertiary formations which occur there.

3. The mining region of Colville Peninsula was visited for the purpose of ascertaining what steps are required for a more thorough survey of the mineral deposits at Coromandel, Thames, Ohinemuri, and Te Aroha, the proper investigation and study of which will alone require several years' undivided attention.

Nelson District.

4. The mountainous country to the south-east of Collingwood, about one hundred and fifty square miles in extent, was explored for the first time, and enabled several previous detached surveys to be connected up.

5. The Picton Coal Basin.

Otago.

6. A belt of country from the mouth of the Waitaki River to the watershed of the Alpine range west of Wanaka Lake, about

four hundred square miles. The details of these surveys are given in the following reports, and the results have been embodied in a new geological map of the colony on the scale of twelve miles to the inch, which is larger than any hitherto prepared, and which will be published as soon as circumstances permit. No important modifications have however been required in the system of classification adopted in last year's report; the chief improvement being that the subdivisions have been depicted in much greater detail, distinguishing the distributional boundaries of Triassic, Permian, Devonian, and Silurian areas that have not hitherto been defined.

MINING.

Besides the rapid development of quartz-mining in the Reefton District, and the extension southwards of the Thames Gold-Mining District to Te Aroha, the chief novelty in mining enterprise during the year has been the discovery of fresh auriferous reefs at Terawhiti, in the neighbourhood of Wellington. It has long been known that this particular district is gold-bearing; and a considerable amount of work both in the way of alluvial mining and reefing has been done, but without any decided results being obtained. In January, however, what appear to be well-defined reefs were discovered accidentally at some distance from the previous workings, and are now being systematically explored. Their real value will probably not be ascertained until a large expenditure has been incurred, but the tests of unpicked samples, taken without any special selection, have afforded most encouraging returns of from 5 dwt. to over 3 oz. per ton.

Chrome Deposits in the Vicinity of Nelson.—The discovery of several new applications of chrome salts in the arts, and notably the proposal to use it for tanning leather, having revived an interest in this ore, various lodes, some of which have recently been discovered, were carefully examined, with a view of determining if they could supply the market successfully at the present prices. The result shows that there are lodes of chromic iron ore in ten different localities, containing from 36 to 64 per cent. of chromic oxide, but that many of them are in such inaccessible positions that they would not pay the expense of carriage. As to this must be added the freight to London, which is 15s. per ton, Mr. Cox is of opinion that, instead of

shipping the crude ore, works should be established for the local production of the bichromate of potash. Mr. Cox also examined the further exploratory works that have been made for opening up the copper lode in Aniseed Valley, and reports that, as a mining venture, its prospects are still somewhat speculative, as for want of capital the exploration of the lodes has not been carried on in a sufficiently satisfactory manner.

The Richmond Hill Silver Mine was also re-examined as far as possible, considering that the main shaft is full of water. It is pointed out that an expenditure of £100 should be sufficient to repair the water-race, and that the present water-wheel would be then sufficient to pump the mine, and afterwards to compress air to work rock-drills, the past failure of the mine being evidently due to the use of hand-drilling alone, which is not suitable for following patchy ore-shoots in such hard ground. As, besides silver varying from 21 oz. to 175 oz. per ton, the ore contains lead, copper, antimony, bismuth, nickel, and zinc, it is certainly worth following up; but it is considered that it would not be advisable to commence with a less capital than £10,000.

The Collingwood Coal Mine was examined, with the view of advising on the most judicious manner of extending the workings.

Attention has lately been directed to the unexplored area of Fiord County, in the west of Otago, and, as some misconception has arisen as to the amount of information we possess about that picturesque district, the following notes supplied to a correspondent may be useful :—

In 1863 I explored to the source of nearly all the streams that fall into Milford Sound, except up the Arthur River towards Te Anau Lake; but Captain Hankinson working from the lake, and Messrs. Sutherland and McKay from the Milford, have cleared that up. These two men have just returned, subsidized to a small extent by Government, to continue their prospecting. They have traversed the country in many directions, and have blazed over eighty miles of track up the valleys from Milford during the last two years. The unexplored country is not in Lake County, but in Fiord County, and lies between Manipori Lake and the head of Dusky Bay. It is, roughly speaking, about twenty miles wide and thirty miles long, and only remains unexplored because of the greater facilities afforded by the rami-

fications of the sounds and lakes for exploring the other parts of the district. The country to the north, between Te Anau and the sounds, has been traversed in various directions by McKerrow, Hankinson, Cox, myself, and others; but, so far as I know, our information respecting the above area is only derived from distant views from mountain-tops.

I do not suppose there will be much difference in the geology or botany from that of the surrounding mountains, but I have always anticipated the discovery of mineral lodes in the higher parts of these great mountain masses.

The wonderful manner in which they are intersected by profound valleys, laying open sections of the earth to depths far beyond the reach of ordinary mining operations, should greatly facilitate prospecting.

The mass of the mountains is formed of the most highly metamorphosed rocks, from the upper surface of which spring the mineral lodes that intersect the less ancient rocks in other parts of New Zealand. Take, for instance, the north-west of Nelson, Reefton, or the Upper Shotover. If the mineral lodes were there followed down below the surface, the crystalline rocks of the Fiord mountains would be encountered under the same conditions which they present—not at the lowest, but—at the highest levels of the West Coast ranges.

It might be expected that the outcrop of the metalliferous rocks could be easily traced along the eastern flank of the crystalline rocks; but attempts to do this have not as yet proved successful, owing to the existence of a great fault that brings the Devonian rocks (my Te Anau series) in direct surface contact with the crystalline schists, thus cutting out the mineral-bearing rocks.

The investigation of these important structural features is kept steadily in view, and worked at when any member of the very limited geological staff can be spared from other work at the proper season. The chief requisites for exploring among the West Coast ranges are patience and sufficient supplies to last over the long spells of weather when bush travelling is impracticable.

With respect to further exploration, the position is this: 1. For minerals, the whole of the West Coast ranges require prospecting and more detailed geological survey, not merely the

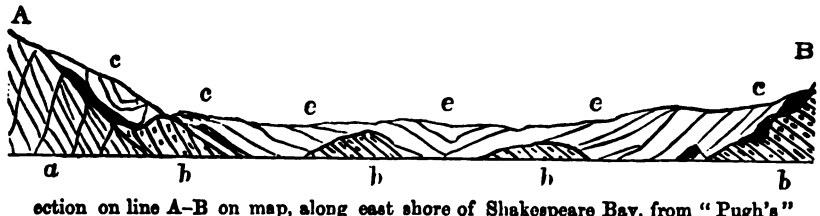
unexplored portions. 2. For settlement or land-survey purposes, further exploration is not at present a pressing want. 3. For botanical and zoological students these mountains afford a splendid field for holiday rambles, as there will be a chance of finding novelties, and the charm of exploring untrodden hills and valleys, to give zest to the excursion.

There have been many prospectors at work in some parts of the ranges, both in the east and the west, inland, but I have had no communication with any except Messrs. Docherty, Sutherland, and McKay.

Picton Coal Basin.—This very interesting outlier of coal, the probable existence of which I pointed out as early as 1864, has attracted much attention of late on account of the excellent quality of the coal and the very favourable position it occupies for shipment, if it were found in sufficient quantity. The locality has been frequently visited by myself and Mr. McKay, and every important step that has been made in exploring the coal has been carefully observed. The surrounding country has also been explored, especially on the top of the schistose ranges to the west, as it is in that direction that patches of high-level or plateau coal-measures might be expected to have escaped denudation. So far the search for these has been unsuccessful, and according to our present knowledge the coal-bearing strata are confined to a triangular patch faulted down between schists on the west and Permian rocks on the east, having an extent of about half a square mile. Along with the coal-measures, which are of Upper Cretaceous age, strata of Eocene Tertiary age have been involved in the same dislocation, and these overlie and obscure the coal-beds, and also occur as a second outlier at the elevation about two miles to the south, but no valuable beds of coal have yet been discovered in the second locality, which appears to be completely detached from the Shakespeare Bay outlier.

The accompanying map shows the relative positions of the deposits. The coal-bearing area in Shakespeare Bay is also drawn on a larger scale, in order to show the relative position of the only workable seams that have yet been discovered (*see* p. 112). The arrangement of the strata is that of a steeply-folded synclinal or trough-shaped formation, about one mile in length and half a mile in width. Boreholes, shafts, and tunnels have been employed to explore this area, but, the works not

having been carried out on any regular system, the exact information gained has not been commensurate with the large expenditure that has been incurred. Coal has been found only round the margins of the area, and the seams have in every case proved to be very irregular in thickness and quality, and to be much disturbed and crushed by local faultings. It has been supposed that these are merely outcrops of coal-seams that pass under the syncline, but nothing has been yet ascertained that tends to establish this hypothesis; or whether, as is not improbable, the area is traversed throughout by repeated faults that would bring the coal to within moderate depths, but always in irregular and crushed masses, like those round the outcrop. The great irregularities which the strata present within short horizontal distances may be judged of by the following sections, which are obtained on the east and west sides of the isthmus or narrow neck of land over which the track leads from Picton Bay to Shakespeare Bay :—



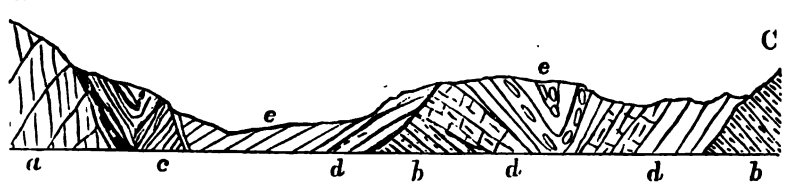
ection on line A–B on map, along east shore of Shakespeare Bay, from "Pugh's" coal, A, to "Fell's" coal at B. *a*. Schists of promontory. *b*. Sandstones and shales (Permian). *c*. Dark marls and sands, with crushed coal-seams. *e*. Concretionary marlstones (Eocene).

On the line A–B, along the east side of Shakespeare Bay, we have at A the mica-schist rock of the high hill that forms the promontory between the two bays. Along the south flank of this hill we find (*c*) dark sandy shales, with green and grey sandstones, containing irregular pipings of coal. These beds are much disturbed, dipping at high angles, and are frequently inverted so as to dip towards the schist rock against which they have been crushed. This is the prevailing character of the junction of the coal rocks with the schist all round the boundary, which can be traced from the west side of Shakespeare Bay rising to the south-west for nearly a mile on the flank of the high range of mountains in that direction. The sandstones of the coal-bearing group are met with at about 600 feet altitude towards the source of Cemetery Creek, but coal has not been found

in this locality. Continuing the section along the east side of Shakespeare Bay, we find the sandstones to be unconformably overlaid by marly sandstones and shales, containing calcareous concretions, from which a few imperfect fossils were obtained, but sufficient to identify the beds as belonging to the Eocene formation, like those at the summit.

At the sea-level two ridges of the old sandstones, probably of Permian age, that form the mass of the mountains to the south-east of Picton, appear for short distances, indicating the extreme shallowness of the trough that contains the coal strata, at least in this line of section.

From beneath the marlstones the coal sandstones again re-appear, resting on the Permian rock, against which they have also been much crushed and dislocated. It is in this position of the section that Fell's coal occurs. It has been explored by a short, irregular excavation executed without any definite plan. The coal appears close to the surface, and had been traced to a depth of 25 feet at the time of my visit, in which distance it varies from 6 feet to 13 feet in thickness. The attempts to trace its extent on the strike of the seam have not been very successful, and the total distance explored, being less than a chain in length, showed that the seam is very irregular, and cut by cross-faults or slips in such a manner as would involve an expensive and insecure process of mining for the extraction of the coal, if followed to the dip. The coal is, at the same time, of very excellent quality, being a powerful steam-coal, and there is no question that from this place a considerable quantity could be profitably extracted by shallow workings. In this way, without much outlay of capital, a better knowledge of the deposits would be obtained, so that the proper method of opening up a mine could be decided on, which is at present quite impossible.



Section on line C–D on map along west shore of Picton Bay at the Isthmus. *a*. Schist. *b*. Sandstones (Permian). *c*. Dark sandy marls with crushed coal in which first tunnel was driven. *d*. Conglomerate and limestones. *e*. Concretionary marlstones (*d* and *e* Eocene).

The section in line C–D is that displayed along the shore of Picton Harbour on the east side of the neck of land, and distant only a few chains from the section just described. Commencing at C, we find calcareous conglomerate (*d*), which was not met with in the other section, resting on the Permian rocks and dipping slightly to north under a narrow syncline of the marlstone (*e*), on the north side of which it again appears with a southerly dip, but is here nearly pure limestone in massive beds and resting again on a narrow ridge of Permian rocks, which shows only on the water's edge. North of this ridge the marlstones are in contact with this ridge, and continue until the crushed sandstone with impure coal-seams (*c*) is brought up with a fault along the boundary of the mica-schist in the position where the first exploring tunnel was put in many years ago.

The comparison of these two sections affords clear evidence of the disturbed and variable character of the strata within short distances, and the necessity for extreme caution in projecting expensive shafts or other works with the view of following the coal to the dip.

AUCKLAND DISTRICT.

Early in the season Mr. Cox paid a visit to the North Auckland District, with the object of revising some of the previous year's work in the North, and of further continuing the survey.

As regards the revision, Mr. Cox has not seen any reason to in any way alter the general sequence which he gave in his last year's report, but thinks it probable that a slightly too high horizon was assigned to the beds from Auckland North, and that in reality they belonged to the Eocene formation, and not Lower Miocene as suggested last year. He makes a special report on the supposed occurrence of coal at Mahurangi, showing that not only have no seams of importance, indeed no more than three inches of coal, been discovered, but that the beds which are being prospected for coal are not even the coal-measures, and, further, that nothing could be proved by boring in this locality which could not equally well be seen in the natural sections exposed in the beds of the creeks. As regards the continuance of the survey, Mr. Cox has examined the country from Auckland south to Mercer, and supplied a map of the same. He subdivides the formations as follow :—

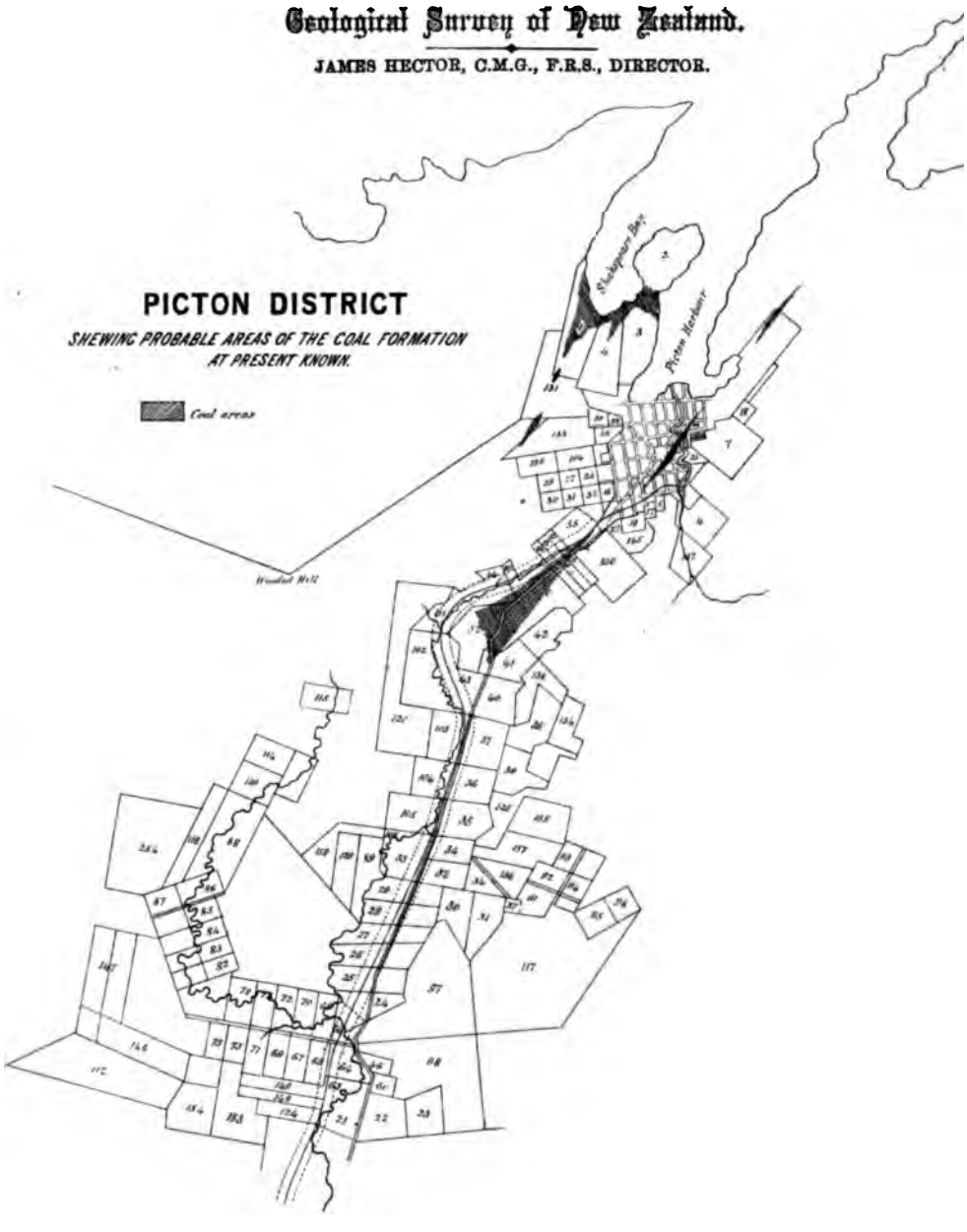
Geological Survey of New Zealand.

JAMES HECTOR, C.M.G., F.R.S., DIRECTOR.

PICTON DISTRICT

SHEWING PROBABLE AREAS OF THE COAL FORMATION AT PRESENT KNOWN.

Coal areas



1. Basaltic rocks.
2. Plastic clays and sands.
3. Waitemata marls and sandstone.
4. Papakura limestone.
5. Coal-measures.
6. Slates.

The slates from the basement rock of the district stretch from Maungatawhiri Flat to Maraetai, on the shores of the Waitemata Harbour; and resting unconformably on these come the coal-measures in which seams of coal have been worked at Drury.

Mr. Cox considers that at Drury the coal measures keep a higher elevation than the flat, and at a short distance back into the hill they dip N.E. at an angle of 15°, which would not carry the coal below the flat, so that the only chance of its occurring there lies in its having been faulted down. Whether this view is correct cannot be decided from surface indications, and boring is the only way to set the matter at rest.

The relations of the Papakura limestone and the Waitemata beds to the Drury coal-measures was not very apparent, and will have to form the basis of a further examination of these beds when occasion offers.

Referring to Mr. Hunt's borehole near Mercer, which has been put down in search for coal, Mr. Cox reproduces a section published with his report in this district in 1877, showing that the borehole is now well down into the Leda marls, which are exposed at the surface on the rise of the hill between Pokeno and Mercer, where they dip at an angle of 33°, N. 30° E. He considers that this dip would give an approximate thickness of 359 feet for the upper blue marls, and, as the borehole has been sunk to a depth of 540 feet and the last 154 feet having passed through hard and soft bands of sandstone and tough marly clay, it is probable that this distance at least has passed through the Leda marls and associated beds.

Summing up the results of his work here, he says: "Whether these Mercer beds are the equivalents of the Waitemata series proper I have no means of judging, and can only state that no apparent unconformity exists between them and the Leda marls as developed in the Waikato. Be this as it may, however, the question of the extension of the coal is in no way altered, as the Leda marls do occur throughout the basin, and until these have

been bored through, and rocks inferior to the coal found, it will by no means be proved that a large coal area does not exist in the Waikato basin."

At Kawau Mr. Cox traces the same relations between the fossiliferous grits and conglomerates, passing at times into an impure limestone, and the sands and marls with thin streaks and pockets of coal which overlie them, and which he considers as the Waitemata beds, as he has shown them to exist on the mainland.

Referring to the older slates and sandstones on the island, he considers that they are the equivalents in time of the lower part of the Maitai series and upper part of the Te Anau series, a serpentinous dyke being considered as the equivalent of the Nelson mineral belt, and the calcareous slates being looked upon as representing the Maitai limestone.

With regard to the minerals which occur on the island, he is disposed to regard the copper lode very favourably, and has summarized several defects in the original working of the mine, which, doubtless, materially assisted in closing it when previously worked. He also points out that the iron ore which is found associated with manganese at Manganese Point is probably a gossan forming the back of a pyritous lode of some sort which, from the presence of cupriferous ores throughout the island, would probably be a copper pyrites.

Mr. Cox has not supplied a map of the island, as, having no change to make from that published by me in 1868–69, it was unnecessary.

He paid a visit to the Thames and Coromandel with the object of tracing the relations between the coal series, auriferous greenstone trachytes, and the Tertiary trachyte of Beeson's Island, and took the occasion to visit several of the mines both at the Thames and Coromandel. He reports that the oldest rocks of the district are the slates of the Tiki, which occupy the northern part of the Cape Colville Peninsula, and both with these and the trachytic rocks which occur both at the Thames and Coromandel, and which are traversed by numerous hard bands, locally known as dykes, auriferous reefs occur: that in the direction of Cabbage Bay the coal-measures are seen, and that an impure seam of coal has been discovered dipping E. at an angle of 30°. The coal contains 35·98 per cent. of ash, but in other respects it is anthracitic in character, and, could a

better sample be obtained, would be of considerable value, although its position as regards means of exit is not good. The extent of the coal-measures has not been proved, but the trachyte breccias, those of Beeson's Island, are shown to rest upon them, as also do they on the slates and older trachytic rocks at Coromandel. He states that these trachyte breccias correspond exactly in character with the breccia-beds of the Manukau Heads, being composed of a coarse volcanic agglomerate traversed by at least one dyke on Beeson's Island, a dolerite dyke also occurring close to the Union Beach Claim, and probably running through these beds. His work in this district has thus confirmed the views I have previously published concerning the relations of the auriferous rocks in the district (Geological Reports, 1870, p. 88).

COLLINGWOOD RANGES.

For two months after Christmas Mr. Cox was engaged on an examination and survey of the mountainous district lying between the Takaka and Aorere Rivers, at the heads of the Slate and Anatoki Rivers. He divides the rocks met with as follows :—

1. Alluvial deposits.
2. Ancient river-terraces.
3. Cretaceo-Tertiary.
4. Upper Devonian.
5. Lower Silurian.
6. Granites and gneissose rocks.

The granites, although of structural importance in relation to the mineral lodes of this district, occupy only a small surface-area in the district, but rise in detached masses to an altitude of about 5,000 feet. They are traversed at places by veins of a nearly pure micaceous rock, which resembles the Richmond Hill lode stuff, and, like that rock, occasionally yields silver on assay.

Gneissose rocks, with which the Richmond Hill silver ore occurs, are found in that part of the Parapara River associated with steatites and talcose rocks, which occur as irregular masses in them, and all evidently due to special conditions under which their metamorphism was locally effected.

These gneissose rocks are interstratified with the beds of crystalline limestone and bituminous and hornblendic schists

which are referred to Lower Silurian age. It is associated with the limestone of this formation that the well-known Parapara hæmatite occurs, which he considers to be the back of a large pyritous lode, giving as his reason for this that the number of pyrites crystals and cores of pyrites which are found in many of the boulders would point to the whole mass having been formed by the decomposition of pyrites. He further mentions the occurrence of a large pyrites lode in the limestone at McGregor's Creek, and argues that in the greater part of the area over which this ore is found it is not *in sitû*, and that a lode of only moderate size would by its degradation soon cover a large surface-area if the outcrop were only exposed on a spur.

Associated with the bituminous schist, veins of an impure graphite occur, but no seams of any value have as yet been discovered. Resting unconformably upon the last-mentioned rocks come the beds of the Te Anau series, which in their unaltered condition consist of porphyries, amygdaloidal tufas, &c., interstratified with beds of greensandstone and fine-grained green breccias, followed by an occasional band of dark-coloured slate: at other places the beds consist of breccia conglomerate, containing a great quantity of quartz, but no porphyritic rocks. The metamorphosed rocks generally occupy the low grounds; but in Snow's River schistose rocks also occur interstratified with the sandstones and slates which form the ranges on each side, of which he gives an interesting illustrative section. They consist of dark-blue laminated clay-slate; but at other places they are fine-grained silky mica-schists with quartzites interstratified; and near the head of the Boulder River, where it comes out of the lake, grey felspathic schists occur with black carbonaceous slates and segregations of quartz, passing down into fine silky slate like those at Reefton; and then come schistose rocks, which closely resemble the Riwaka schists, with garnets.

It is in this group of rocks that the auriferous reef occurs which was formerly worked by the Perseverance Gold-Mining Company, and the same ground in Bedstead Gully is now being prospected for the galena and zinc-blende which were formerly found there.

The Cretaceo-Tertiary series consists of limestones and calcareous sandstones, which rest unconformably upon the last-mentioned series. They occur as patches skirting the older rocks and lapping up into them to an elevation of about 1,800 feet at

the Castles, and stretching up the valley of the Waitui to join beds of the same age mapped by Mr. McKay in the Mount Arthur District. A fine collection of fossils was obtained from these beds in a road-cutting at Silverstream, near the junction of Salisbury's Creek with the Aorere River. Some very fine specimens of aragonite and calcite were also obtained from the limestones of these beds.

With regard to the auriferous wash of the Quartz Ranges, Mr. Cox adopts the hypothesis that it was in all probability originally formed by a river flowing from the direction of the Gouland Downs towards the Parapara, and at a much greater elevation than that taken by the Aorere now: he further points out that this river was in all probability fed by glaciers, so that the rocks may have been brought for a considerable distance. The fact that quartz forms the principal constituent of the gravels may be accounted for by its resistance to disintegration compared with the comparatively soft rocks with which it was associated.

These beds have since been cut through by a lateral drainage, and the gold concentrated by natural means in these cross-channels, and it is doubtless to a large extent from these, though not altogether, that the Aorere gold has been derived, the Te Anau series doubtless supplying to a less extent the alluvial gold of the district.

WAITAKI VALLEY AND ALPS OF NORTH OTAGO.

In August Mr. McKay was instructed to devote his work during the following summer to an examination of a belt of country stretching from sea to sea along the boundary dividing the Provincial Districts of Canterbury and Otago, and to collect material for the construction of a section illustrative of the general sequence of the formations present in that part of the South Island. The early part of the season was spent in the eastern district constituted by the lower part of the Waitaki Valley and in Southern Canterbury by part of the area drained by the Waihao River. This part of the district being peculiarly rich in fossiliferous deposits, both of Tertiary and Cretaceo-Tertiary age, very considerable collections were added to those already obtained by the Geological Department from the same district.

Before dealing more particularly with the work done and the collections obtained from this part of the district, it will be

necessary to state what, apart from the general aim, was more particularly sought to be accomplished. In doing so it will be necessary to remark that the classification of our Lower Tertiary and Upper Cretaceous deposits is a problem of considerable difficulty, but at the same time of great importance as affecting the probable presence of coal deposits in particular areas, and the question whether or not these occur as workable seams in two or more horizons. In the classification at present adopted the coal-bearing strata of the North Island and the east coast of the South Island are all considered to belong to the base of the Cretaceo-Tertiary series, and with some unimportant exceptions this rule appears to hold good. The synchronal deposition of the strata forming our various coal fields is evidenced by a close similarity in the character and sequence of the strata, and at the same time by a decided community of character in the fossils of widely separated districts. The objections which have been suggested against the present classification appear to rely for substantiation on the fact that the fossils of certain localities are not in every respect those found in other localities, and thus, while the Cretaceous age of the beds in some districts is not disputed, in other localities the coal series, although lithologically the same in character, and closed by beds acknowledged to be the equivalent of those terminating the admittedly Cretaceous rocks, are, on account of a more Tertiary aspect of their fossils, pronounced to belong to a younger formation.

In Northern Canterbury, as far south as the Rakaia River, the coal rocks are overlaid by fossiliferous strata, which, besides the Plesiosauroid reptiles for which the Waipara District is famous, contain a few secondary genera, such as *Belemnites*, *Aporrhais*, *Inoceramus*, and *Trigonia*; but the great mass of the associated molluscan fauna agrees with that of the coal rocks in other parts of New Zealand, where the specially Cretaceous forms are rare or absent from the fossiliferous horizons immediately overlying the coal-seams. If, therefore, after eliminating the comparatively few fossils which form the peculiarities of two localities, the bulk of those remaining are found to be the same, there need be no hesitation in considering strata showing the same succession of like characters in its different divisions as belonging to the same series; and, if in any one of these localities there is evidence that the beds are of Cretaceous age, the other must be regarded as of that age also. But if, in addition to this,

there be, in those localities where the lower beds lack fossils proving their Cretaceous age, a presence of Cretaceous forms in the higher beds of the same series, the correctness of the correlation will in this way be corroborated. It is partly by evidence of this kind that the Cretaceous age of several of our coal-bearing areas is sought to be established.

In South Canterbury, on the east coast of Otago, and on the west coast of the South Island markedly, Cretaceous fossils are found in the calcareous members of the higher part of the coal-bearing series. The Cretaceous character of the Echinodermata found in the Cobden limestone, also present in the Ototara stone, warrants the reference of these beds to a period anterior to that of any Tertiary deposit in the Islands, the oldest of which is at least Middle Eocene, and separated by an unconformity from the underlying beds. To distinguish these latter the term "Cretaceo-Tertiary" has been made use of, as it is believed that the series bridges over the gap which separates the Lower Eocene from the Cretaceous rocks of Europe. In the Waitaki Valley, and in the same district as far south as the mouth of the Kakanui River, Tertiary rocks comprising limestones and calcareous greensands belonging to the Upper Eocene period are present, resting indifferently on various members of the Cretaceo-Tertiary series, and on those rest as a rule the Tertiary rocks of Lower Miocene age represented by the Pareora and Awamoa beds: these latter are at many places overlaid by heavy beds of gravel and sands, which from their very nature must be considered distinct from the lower, marine portion of the Pareora formation.

Besides the younger gravels belonging to the Pleistocene and Recent periods there are near Timaru and Oamaru considerable deposits of *loess*, which occur in localities where ordinary denudation has progressed but slowly. Near Oamaru this deposit wraps itself round the Cape Hills as a thick slope deposit, which, when cut into, as has been done during the progress of the harbour works and the formation of a breakwater at that place, is shown to contain Moa bones and other terrestrial remains. This deposit is thickest where it overlies rocks of volcanic origin extending for about two miles west of Oamaru, and thence following the volcanic rocks in the direction of their strike northwards along the banks of Oamaru Creek. Considerable deposits of the same material are met with in the upper part of

the Waireka Valley, near Tinarika, in which Moa remains are also found, the loamy material being there underlaid by a few feet of coarse bouldery gravel, as seen in sections exposed along the railway line from Oamaru to Ngapara. Similar deposits wrap round the lower slopes of the hills six miles north of Oamaru, near the junction of the Oamaru–Duntroon branch with the main line of railway. Near Timaru these deposits are of considerably greater extent, covering all the Timaru downs, stretching north-east and south-west from the north bank of the Pareora River to the Washdyke, six miles north of the Town of Timaru. According to Professor v. Haast this deposit stretches west to the eastern slopes of Mount Horrible, on the northern side of the lower gorge of the Pareora River, and thence to the sea at Timaru is underlaid by volcanic rocks. It is noticeable that no river or creek of any size takes its rise in or flows across this area, and that such streams as do flow across these downs, and have cut through the looser deposits, and their channels now lie in the volcanic rocks at the base of the loamy deposits. (*See* Report on Water Supply for the Town of Timaru, by Dr. v. Haast.)

Under the head of "Alluvial and Glacier Deposits," the report deals with a variety of deposits scattered widely over the whole district, the remarks on which are necessarily of a somewhat general character, as much time and careful study will be required to make clear the varying and complicated relations of these deposits. The district comprising the delta of the Waitaki and the coastal plains (stretching to the north considerably beyond the limits of the country mapped) is, though less in size, analogous in the mode of its formation to the Canterbury Plains further to the north. The exact mode of its formation has excited a considerable amount of discussion. In the middle part of the Waitaki Valley heavy gravels, apparently derived from some distant source, are noted in positions which would indicate that considerable changes have taken place in the level of the river-bed since their deposition. Further to the north-west the great extent of shingle flats forming the Upper Waitaki and Mackenzie country plains yields important evidence as to the extension in former times of the glaciers of the main chain of mountains. But the evidences of glacier action met with both above and below the Hakateramea junction are not such as need be referred to an extension of the glaciers of the main range, as they may

have been produced by local glaciers supplied by the mountains of the near neighbourhood. From this it appears that there is no necessity to suppose that the glaciers of the Mackenzie country extended much farther than there are indications of their presence yet to be detected in the morainic accumulations which surround the lower ends of the present lakes. That the level lands of the Mackenzie country are not the result of the excessive denudation of the district during the glacier period, and of the action of ice, is indicated by the presence of an extensive development of young Tertiary rocks, well seen in the south-western part of the district, showing that long prior to the advance of the glaciers, of which evidence now remains as superficial deposits, an extensive depression had been formed and partly refilled in the area now occupied by these plains. Exactly the same result is the outcome of an examination of the deposits underlying the glacier drifts surrounding the lower ends of Lakes Wanaka and Hawea, where the same Tertiary beds are seen to underlie the glacier and river deposits, forming extensive flats in that district.

Pareora Gravels.—These beds, for no better reason than that they are usually found overlying the fossiliferous Pareora beds, have frequently been spoken of as the higher part of the Pareora formation. They have probably no connection with the series of strata with which they have in various reports been associated. Their development in the South Island is very extensive both on the east and west coasts. In the district immediately north and south of the lower part of the Waitaki they are found capping the fossiliferous Pareora beds, and rising to a height of 600 feet on the hills between the Lower Waitaki and the Waihao Rivers. The beds there are mentioned by Professor v. Haast as proving that the Waitaki formerly ran at their highest level. With the Waitaki Valley as it now is these beds have no direct connection, since they abundantly show that movements of the land involving a considerable alteration of its surface configuration have taken place since their deposition, the beds being frequently tilted at high angles, especially in districts distant from the coast-line.

Beds of lignite are present with the sands and clays forming the lower part of these gravels, and according to the present report the coal-seam at Wharekauri, in the Waitaki Valley, is of this age. These same beds are largely developed and are

supposed to contain beds of lignite between the Ahuriri and Ohou Rivers, in the Mackenzie country. Nowhere is it definitely known that marine fossils occur in these beds, but in two distant localities fossils have been found which are referred to this horizon: first at the Mataura Falls, where marine shells are found interbedded with the lignites worked at that place; and secondly in the Trelissick Basin, in sandy beds which cap the lignite overlying the Pareora beds in that locality, as lately discovered by Mr. J. D. Enys, F.G.S. The fossils largely belong to living forms of mollusca, but the percentage of recent species has not yet been determined.

Pareora Beds proper.—These richly fossiliferous beds were collected from in the ranges of hills between the Lower Waitaki and Waihao Rivers, of which Mount Harris is the principal locality whence collections have hitherto been made. The beds described as sands and sandy or marly clays with concretions form the youngest of the fossiliferous Tertiary deposits in the district. As a rule they rest without any marked degree of unconformity on Tertiary rocks of Upper Eocene age; but between the Waitakau and Waihoa Rivers these are absent, and the Pareora beds are underlaid by Cretaceo-Tertiary rocks, and rest on different members of that series or on the older Palæozoic rocks. A good collection was made from the rocks from Mount Harris. Supplementary large collections were made from the same beds at Awamoa, and from the lower and upper parts of the Pareora River. These rocks, extensively developed throughout the Islands, have been assigned a Lower Miocene age, in virtue of their stratigraphical relations to other fossiliferous beds in the northern part of the South Island, and on the east coast of Wellington in the North Island, where Upper Miocene rocks overlie them. Since the publication of the catalogue of the Tertiary Mollusca and Echinodermata by this department in 1873, large additions have been made to the collections then examined, and the percentage of extinct forms has been greatly augmented, so that the 34 per cent. of recent forms, which then was taken to indicate an Upper Miocene age for the beds, has been reduced, the additional recent species added to the collections, compared with the extinct forms, not maintaining the same proportion.

From Mount Harris a collection numbering about five hundred specimens, and containing forty different species of

shells, was obtained. The greatest number of species are univalves, with but few genera of bivalve shells, notably *Corbula, Venericardia, Crassatella,* and *Limopsis;* Brachiopoda being entirely absent.

Hutchinson's Quarry Beds.—In Southern Canterbury and Northern Otago the highest member of the New Zealand Eocene rocks, the Mount Brown beds, do not appear to be present, and of this period the youngest rocks met with are the Hutchinson's Quarry beds. The relations of these to the Pareora beds indicate but a slight degree of unconformity, such not being stratigraphically apparent in the neighbourhood of Oamaru, from which district the greatest number of fossils have been obtained from these beds. It should be explained that the fossils of this horizon, principally obtained from Hutchinson's Quarry, have often wrongly been understood as representing the Ototara limestone or Oamaru stone, which, being separated from the Hutchinson's Quarry beds by a series of volcanic rocks, belongs to the upper part of the Cretaceo-Tertiary series. The fossils, however, are correctly enough referred to the Upper Eocene, comparatively few of these having in the early collections been obtained from the Ototara stone. In the Waitaki Valley the Hutchinson's Quarry beds are not well developed, and are recognized as a distinct group in the neighbourhood of Wharekauri only, where, as loose sandy beds, they overlie the Otakaika limestone. In this locality the beds are full of fossils, but there is less variety of species than at Oamaru. *Waldheimia triangulare* occurs in great numbers, but unaccompanied by the variety of brachiopods which are found at Hutchinson's Quarry. The other prominent forms are *Natica solida* (?), *Venericardia intermedia, Limopsis isolata, Pecten hochstetteri.* Altogether about a hundred species were collected from this horizon in the Wharekauri section.

Otakaika Limestone.—This rock, which is rich in fossil remains of a type considerably different from those of the Maerewhenua limestone, is in the present report considered to belong to the Eocene rocks and to the horizon immediately underlying the Hutchinson's Quarry beds. It thus occupies the position of the Nummulitic limestone in other parts of the colony. The rock is a soft calcareous sandstone, slightly glauconitic, and in places rich in a variety of minute Foraminifera, which are usually not visible except by aid of a pocket-lens. It is crowded with

shells, the larger forms occurring in layers at intervals. Of these, *Cucullæa worthingtoni* is very abundant and of large size. Among the described shells this species and *Dentalium giganteum* characterize the Otakaika limestone and the underlying beds, between the fossils of which there is no material difference.

Collected from at three distinct localities a considerable number of species have been obtained, the identification or description of which has not as yet been undertaken.

Kekenodon Beds.—This term has been applied to a series of green and grey sands which, underlying the Otakaika limestones, form in the Waitaki Valley the lowest of the Eocene rocks, and are, from their position, the lowest Tertiary beds yet found in New Zealand. So far as known the beds are local to the middle part of the Waitaki Valley, as below the Hakateramea junction the higher Eocene rocks are not underlaid by these beds, but rest on the older Palæozoic rocks. The beds are rich in a very considerable variety of fossils, which closely resemble those of the overlying limestone. Of these a large collection was made, the most notable of which are the remains of a gigantic Zeuglodont Cetacean, which I have described under the name of *Kekenodon onamata*. (Trans. N.Z. Institute, Vol. XIII., 435, Pl. xviii.)

In time these beds probably represent the Middle Eocene period, and may have been deposited during or before the eruption of the lower part of the volcanic rocks surrounding the Town of Oamaru.

Cretaceo-Tertiary.

Grey Marls. — These beds are doubtfully present in the district; but in a previous report beds found capping the limestones on the north bank of the Maerewhenua River were referred to this, the highest horizon of the Cretacco-Tertiary series. The rocks as sandy beds with cement concretions resemble the Parcora beds, while the fossils resemble those from Hutchinson's Quarry and the Otakaika limestone more than those of the grey marls. The beds were not collected from on this occasion.

Maerewhenua and Waihao Limestones.—These are considered to be the equivalents of the Ototara limestone, and in these fossils are easily distinguished from the Hutchinson's Quarry beds. Brachiopoda and Echinodermata are plentiful in these beds in both localities, and the collections of this year added to

those already obtained one or two species not previously obtained. The collection from the Waihao limestone, though not numbering more than a hundred specimens, has several rarities. There are fine examples of a large form of *Cidaris* (?), which appears to have carried enormous spines, some of which spines found in the Maerewhenua limestone are more than a foot in length, exhibiting in polished sections both a radiate and a concentric structure. These spines, compared with examples (*Belemnites senescens ?*) forwarded from South Australia by Professor Tait, are in every respect identical. Plates and spines of the New Zealand form abound in various localities, and occur in the Eocene rocks of the Curiosity Shop and the Otakaika limestone, so that it does not prove that the Waihao or the Maerewhenua limestones are the equivalents of the Australian deposits in which the same fossil has been found.

In the collection from the Waihao limestone there are other forms of Echinodermata, which, till collected on the present occasion, have only been known to occur in the Cobden limestone on the west coast of the South Island.

Chalk-marls, occupying the horizon of the Amuri limestone, were detected in one locality only, where, along the south bank of the Waihao River, they are seen to underlie the Waihao limestone. Where directly underlying the limestones the beds are a light-grey chalky clay; fossils are rare, and only a few Foraminifera were observed. At another locality where the limestone has been denuded and the beds of this horizon are more in contact with the Pareora clays, and where the beds differ somewhat in character, but occupy exactly the same position in relation to the underlying rocks, abundance of fossils are present. This locality, situated at the point where the river leaves the hills to cross the shingle-plains between there and the sea, shows dark foraminiferous marls overlaid by a tufaceous conglomerate followed by greensands. *Pecten zittelli* occurs abundantly in the sandstones; and in the tufaceous conglomerates which underlie the sandstones numerous examples of *Balanophyllia huttoniana* (?) —a West Coast fossil—are found. The dark foraminiferous marls which rest on dark greensands closely resemble the black marls which at Greymouth underlie the Cobden limestone.

Marly Greensands.—These beds are largely developed in the Waihao and Waitaki Valleys, and in both places contain a variety of fossils. In the Waihao district a species of *Limopsis*,

resembling *Limopsis zelandica* found in the Pareora beds, is the most abundant shell; but with this are other forms peculiar to this horizon, the most notable of which is a large Nautilus *(Aturia ziczac)*, while in the Waitaki Valley another form of equal size is found, and from the same beds considerable numbers of the fossil crab *Harpactocarcinus tumidus*, first found in sandy clays overlying the Island sandstone at Brighton, on the West Coast.

From the two localities at which these beds were collected from, 250 specimens were obtained.

Island Sandstone.—These beds were examined in the Waihao basin only, having been previously collected from at Black's Point, in the Waitaki Valley. This is the lowest fossiliferous horizon overlying the coal, and yields a fossil fauna very distinct from the higher beds of the Cretaceo-Tertiary series, and which itself is variable in different localities. From the Waihao River the fossils are the same as those found at the Kokohu and at Black's Point, where in both places the fossiliferous beds lie at no great distance above the coal-seams. A collection of 400 specimens, mostly in good condition and preserving the shell, was made from these beds in the Waihao.

Coal-beds are found underlying the Island sandstone in the Waihao, extending from the point where the river enters the hills to Elephant Hill: at most places, however, the seams are thin or of inferior quality. In the Waitaki Valley, north of Awamoko, workable coal belonging to this horizon has not been found, the coal-seam worked at Wharekauri being regarded as of Tertiary age.

Triassic and Permian Rocks.—Of the older rocks forming the framework of the country, the youngest, lying within the Hakateramea Valley, are referred to the above formations. In the older drifts forming the superficial deposits of the middle part of the Waitaki Valley, numerous blocks containing Triassic and Permian fossils are found, and the inference is that the rocks on the northern side of the valley have yielded these. Be this as it may, fossils not being found *in sitû* the age of the rocks in question must be determined by their position in relation to the beds which underlie. These being partly Maitai (Carboniferous), it follows that rocks younger than these are necessarily not older than Permian, and the probability of their being such is shown by the presence of the fossils as above mentioned. The extent

of this formation in South Canterbury was not determined, and its extent in Northern Otago, bounding on the Mackenzie country, was but approximately determined, and without any proofs of its age further than its stratigraphical superiority to the Carboniferous rocks which on three sides bound this development of Old Secondary and Permian strata.

Maitai and Te Anau Rocks.—These rocks are extensively developed along the line of country examined, as far as the borders of the schistose country on the east side of the Lindis Pass. Along the lower part of the Waitaki Valley, and in the ranges between the Waihao River and the Seaward Plains, rocks are found which yield some obscure fossils belonging to the Maitai period, while in places the rocks themselves closely resemble those of the Te Anau series, and there has thus been a difficulty in defining the boundaries of the two formations in this part of the district. In the upper part of the Waitaki Valley the unaltered rocks forming the ranges in the south-west part of the Mackenzie country are with more certainty referred to the higher formation, the Maitai series, the rocks of which, forming the crest and eastern declivities of the Southern Alps, rest on the schists to the exclusion of unaltered Lower Devonian or Silurian rocks, which formations are in this part of the Island probably represented by metamorphosed rocks.

Walter and Cecil Peak Series.—Under this head is described a series of subschistose rocks forming the Kurow Mountains, and which are identified as being the same as those mentioned in last year's Report "On the District West and North of Lake Wakatipu." In this instance the rocks were not traced sufficiently to the south-west, so as to show their relations to the lower schists of the Mount Ida Range, their relations to the foliated schists on the west side of the great anticline being last year shown to be highly unconformable.

Foliated Schists.—To the middle division of these are referred the rocks of the Shotover Valley, striking north across the ranges to the valley of the west branch of the Matukituki River, and thence across the main range at the source of that river. Also to the same horizon are referred the blue schists of the middle part of the Lindis Valley. In both districts these rocks rest on the lower or contorted schists.

On the west of the anticline, either forming the base of the middle schists or constituting isolated patches of a much younger

formation, lie the Black Peak rocks. These are composed of a very considerable thickness of grey and pink-coloured quartzites, associated with intrusive syenitic and trappean rocks of different varieties, and an association of minerals that affords highly favourable indications for the existence of metalliferous lodes in the mountains west of the Matakitaki, a district that has not yet been explored by miners. As far as present examinations have thrown light on the stratigraphical relations of these rocks, it would appear that they pass under the middle division of the foliated schists, but from the excessive ruggedness of the district the proof of this was inferred from that part of the section lying further to the westward.

Lower or Contorted Schists.—These rocks form the country for some distance on both sides of Lake Wanaka, to the north and west of which they have generally a southerly dip, which farther to the south-east alters to a north-east and south-west dip along the two wings of the great anticline intersecting the central region of Otago in a south-east and north-west direction.

JAMES HECTOR,
Director.

GEOLOGICAL REPORTS, 1881.

CHROME ORES OF NEW ZEALAND.

Report by Dr. Hector.

The only form in which the metal chromium occurs in sufficient abundance to be of economic importance is that of chromite or chromic iron, a combination of oxide of chromium with protoxide of iron and oxide of magnesia. This mineral does not occur in fissure-lodes or intersecting veins like most other metallic ores, but most frequently as a result of local metamorphic action in magnesian rocks, resembling the manner in which garnets have been found in certain schistose and crystalline rocks.

For this reason such deposits are somewhat difficult to follow, and the opening up of chrome mines is frequently attended by many disappointments. There is however no reason to doubt that deposits of this mineral are to be found in New Zealand under circumstances quite as promising for successful working as in the few other parts of the world that supply the market with this ore at the present time.

Chrome iron ore occurs associated with the serpentinous rocks of the mineral belt at the Dun Mountain, Nelson; in D'Urville Island, and throughout the district from there to Jackson's Bay, wherever these rocks occur. It is also found in the serpentinous series of the Greenstone and Lake Wakatipu districts.

The chrome ore forms wedge-shaped masses in the serpentine, which vary in thickness from a few inches to as much as 12 feet. The ore is massive or more rarely crystalline in its texture, generally pure, but occasionally traversed by thin streaks of serpentine. The veins are generally discovered by their cropping out at the surface for a few fathoms in parallel lines, but never form continuous lodes, nor are they continuous in depth. It also occurs as grains, scattered through the olivine rock which forms the Dun Mountain, and with this mineral constitutes the rock called "Dunite" by Professor von Hochstetter.

Chromic iron, which is chiefly used for the manufacture of dye-stuffs, contains about 45 per cent. of chromium, and was worth, before the discovery of the aniline dyes, £10 10s. per ton, and the present application of it to tanning will probably tend to again raise its price.

About 5,000 tons of ore have been raised at the Dun Mountain, and the single deposit thus opened exposed a further estimated quantity of 10,000 tons, but many other deposits have since been discovered which would greatly increase this amount.

The Dun Mountain Mines, which are at an altitude of 2,500 feet above the level of the sea, were connected with the Port of Nelson by a line of railway twelve and a half miles in length, and having a gradient in a great part of its course of 1 in 18: since, however, the mines were abandoned the rails have been taken up and removed. The shipments of ore amounted to 4,500 tons, which were delivered in London at a cost of £3 13s. per ton.

On the same belt of mineral ground as the Dun Mountain several other mines have been opened, in a line extending for fifteen miles, but ore has only been shipped from three of these mines, which possess the same general characters as the Dun Mountain Mine, without however the occurrence of dunite or some of the other minerals which might otherwise have been supposed to be the necessary accompaniments of the metallic ores. Dunite has also been discovered near Jackson's Bay and again at Milford Sound, where it contains chromic iron, and passes into "jade" or "Maori greenstone."

At Aniseed Valley Mine, a few miles south of the Dun Mountain, which was discovered in 1861, the chrome ore is in serpentinous schist, between a mass of elvanite with copper on the west, and a band of limestone on the east; while Black Reef and Ben Nevis Mines, still further south, occur in a tough green serpentine. From all these deposits, if worked together, a steady supply of the chrome ore could be obtained, if there was any demand for it; but the mines would not be equally profitable, owing to a difference in the quality of the ore and in the facilities for shipment.

Appended is a tabular statement of the percentages of chrome oxide contained in the various samples which have been analyzed at the Colonial Laboratory.

TABULAR STATEMENT OF ANALYTICAL RESULTS OBTAINED IN COLONIAL LABORATORY UPON CHROME ORES TO DATE, AND IN ORDER OF RECEIPT.

No.	Locality.	Chromic Oxide.	Contributor.
		Per cent.	
2721 (1)	Starveall	44·21	Mr. T. Hacket.
„ (2)	Little Ben Nevis Mine	40·62	„
2729 (1)	Brissenden Lode	44·61	„
„ (2)	Aniseed Valley	41·16	„
2748 (1)	Maungatapu	47·69	„
„ (2)	„	64·26	„
„ (3)	Adams's Lode	64·63	„
„ (4)	„	60·64	„
„ (5)	„	56·94	„
„ (6)	„	51·61	„
„ (7)	Little Ben Nevis	55·39	„
2767	Croixelles	43·44	Mr. T. Cotterell.
2768 (1)	Aniseed Valley	42·65	Dr. Irvine.
„ (2)	Maungatapu	52·46	„
„ (3)	Wangamoa	64·80	„
„ (4)	Wairoa	48·92	„
2776	Lake Harris Range (Otago)	61·24	Survey (Mr. McKay).
2812	Little Ben Nevis	59·52	Mr. T. Hacket.
2843 (1)	Wangamoa	57·37	Dr. Irvine.
„ (2)	Dun Mountain	61·60	„
„ (3)	Maungatapu	36·04	„
„ (4)	„	30·18	„
2865 (1)	Dun Mountain (below tramway, altitude 2,500 feet)	63·72	Survey (Mr. Cox).
„ (2)	Dun Mountain (head of brooklets, 10-foot reef)	44·75	„ „
„ (3)	Wangamoa	58·17	„ „
„ (4)	„	52·17	„ „
„ (5)	Little Ben Nevis (Hacket's line, 1,900 feet altitude)	57·65	„ „
„ (6)		52·88	„ „

Average, 50·62 per cent.: 28 analyses.

CHROME DEPOSITS OF NELSON.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

INSTRUCTIONS FROM DR. HECTOR TO MR. COX.

9th December, 1880.

IN consequence of a letter from Dr. Irvine to the Hon. the Minister for Public Works, and agreed to by him, I wish you to proceed to Nelson by the first steamer, to examine and report on the deposits of chrome iron ore which occur there.

Dr. Irvine's request is as follows:—

1. That the Director of the Geological Survey, or some officer of the department, be instructed to report on the chief chrome deposits in the colony, and that a sufficient number of analyses of the ore be made to show its commercial value.
2. That a quantity, not less than five tons, of the ore be sent to the office of the Agent-General in London (if from different places, each parcel to have a label denoting the locality), and that he be instructed to furnish samples to six of the principal manufacturers of bichromate of potash in Great Britain.
3. That firms desirous of trying the ore be furnished with, say, one ton each free of cost, on condition of reporting on its value after trial.

Dr. Irvine has agreed to deliver five tons of the ore on the Government wharf at Nelson free of charge, and I wish you to assist him in selecting the most favourable localities from which to obtain the ore.

In your work you may find it necessary to re-examine the deposits of chrome ore already known throughout the district, and any fresh discoveries, and to select and forward specimens, labelled, for analysis, with the description of their localities, probable extent, and their distance from Nelson, as well as the difficulties which exist to their transport.

You will understand that the information required has relation to the price at which this ore can be placed on the London market, as well as its value when there, and you will be careful to omit no point from your report which can affect these in any way.

You will also inspect the new workings in the Aniseed Valley Copper Mine, and report to me concerning it.

JAMES HECTOR.

REPORT.

1st January, 1881.

I HAVE the honor to inform you that, in accordance with your instructions, dated December 9th, 1880, herewith appended, I have examined some of the principal known outcrops of chrome ore in the Nelson District. I have, however, been prevented from completing my work, in the first instance by the weather, and subsequently by the holidays, and have accordingly thought it better to defer the completion of my examination until after my return from Collingwood.

The following are the results of my work as far as I have gone:—

Wangamoa.

At Wangamoa, where Dr. Irvine and Mr. Tatton are joint proprietors of a claim from which some extremely good samples of

ore have been forwarded, I regret to state that at present no reef has been found; small segregations of chrome iron, the largest of which is 4 feet through, being all that have yet been obtained. A drive is being entered across the line in which these boulders have been found, with the hope of striking a reef, but up to the present this drive has not been carried far enough to cut the line, and accordingly nothing is known beyond what can be seen on the surface.

The place where the workings are being carried on is not more than two miles from the coast, but should the ore be found it would have to be taken in punts as far as deep water, and then shipped in small craft to Nelson to be once more handled.

The country around Wangamoa is not so convenient for prospecting as at other parts of the mineral belt, since the ground is all covered with a considerable deposit of surface soil, while at most other localities it is notorious for its barrenness.

Notwithstanding the fact that very rich chrome ore has thus been found in the Wangamoa district, I cannot recommend any shipment of ore being made from this locality for a test, since the quantity available at present is not sufficient for any output of importance, nor do the surface indications give sufficient promise of permanent work to render any test made of the character of the ore of practical use.

Dun Mountain and Maungatapu Districts.

Chrome ore again occurs on the Dun Mountain lease below the tramway, and near the saddle above the manager's house. Three outcrops have been found between here and the Duck Pond, the highest one, which occurs at an altitude of 2,500 feet, consisting of a finely crystalline chrome ore, the reef not being sufficiently defined at this point to admit of any conclusion being drawn as to its probable extent. Further down towards the Roding River an outcrop of olivine and chrome occurs, and this has been opened sufficiently to show that a defined belt of it exists. A few chains off, I am informed that a continuation of the crystalline reef has been traced, but this Mr. Tatton was unable to find at the time I was there, so I am unable to say anything about it.

There appears to be a good deposit of chrome ore on the Roding River lease, and reefs are reported at Maungatapu and the head of the Miner River, a branch of the Roding River: these reefs, however, I have been unable to see, as I have previously explained, but hope to do so on my return.

Dr. Irvine and Mr. Tatton are, I understand, interested in all these districts, and if the reefs are really to be found, as I am informed on all hands they are, I am of opinion that Dr. Irvine's best localities from which to obtain ore for shipment to the Agent-General would be the Dun Mountain and Maungatapu leases, as there is doubtless ore of good quality at both places. My remarks,

however, regarding the Wangamoa apply equally here, and I do not consider it will be any test to ship five tons of ore without previously proving that a similar class of ore can be supplied from the same localities to the extent, say, of 500 tons, and with a probability of greater quantities being found. I hope to be able to give a favourable report on this head after I have visited the outcrops on my return.

The expenses attendant upon bringing the ore from the Dun Mountain or Maungatapu to Nelson would not be slight, but if the two leases were worked conjointly the expense of connecting both mines with a road up the Maitai River would not, perhaps, be so very great, and in both instances, I believe, a cart road would be quite practicable.

With regard to the Miner River, any works there would necessitate the continuation of the Aniseed Valley Road for some miles, and represent at least ten or twelve miles' cartage to the railway; but if the deposits should prove of considerable extent this would not be very serious: in the meantime, since nothing has been done on the surface, it yet remains to open up the reefs before the question of road-making need be considered. At the Serpentine River, Hacket's old workings have, I understand, been exhausted, but an outcrop has been found on the opposite side of the river in the Aniseed Valley Company's lease. As what small works had been undertaken had fallen in when I was there, I cannot speak of the character of the deposit, but the specimens I saw were inferior.

The Black Reef, which was also formerly worked by Mr. Hacket, is now covered by fallen rocks, and beyond the presence of chrome nothing can be seen, but Mr. Hacket informs me it was about 3 feet wide on an average. He is not certain whether he had worked out the deposit.

Little Ben Nevis.

At Little Ben Nevis, where the mineral belt is of no great width, Mr. Hacket and Mr. Roberts have opened up a deposit of chrome ore, the outcrop being at an altitude of 1,900 feet above the level of the sea. This is the best-defined band of ore I have seen in the district, and the one on which the most systematic work has been expended. There are two points on which work has been commenced, one 50 feet below the other. At the upper level there are two bands of ore, one 10 feet thick and the other 4 feet, separated by a few feet of serpentine, and at the lower level the main band appears to be about 10 feet thick; besides which, there are two thin cross-bands or leaders, which also carry good chrome. These bands of ore vary a good deal in quality, as will be seen from the table of analyses; but since the inferior class consist principally of small segregations of chrome, about the size of a bean, in a soft decomposing serpentine, this could by jigging be dressed in a very simple manner to yield a high percentage.

Mr. Hacket considers that there is a belt of country about 24 feet wide carrying chrome, and that probably one-third of this would consist of available ore; and I think he is quite within the mark in his estimate. I should judge that about 200 tons of stuff had been moved from these outcrops, and, up to the present time, a great deal of second-class ore, which should have been stacked and preserved, has been thrown with the enclosing rock down the spoilbank.

Should this mine be opened for work the most ready means of bringing the ore down to the flat ground would probably be by a wire tramway, of which a length of about two miles would be required. From Mr. Nesbitt's, where the ore would be landed, there is a cart road down the Wairoa Gorge to the railway at Brightwater, a distance of about six miles, and the length of railway from there to Nelson is twelve miles. It will thus be seen that the cost of transport would be considerable, and will form an important item in the calculations which will have to be made before opening the mine. Mr. Hacket has an order for twenty tons of ore, of which about five tons has been brought down, and another eight tons is out and stacked; the trial shipment of ore appears to be of very good quality.

I understand that prospecting licenses have been taken out about the Croixelles, Admiralty Bay, and on D'Urville Island, but I have not visited the localities, and understand that no work has been expended there in the search for chrome. It appears, however, that chrome ore in one form or another exists throughout the length of the mineral belt, and, when it is considered that nearly 5,000 tons was taken out of a single deposit on the Dun Mountain lease, it appears probable that further valuable deposits will yet be found. From the character of these deposits it is quite impossible to form an accurate estimate of the value of a mine from mere surface indications, and, before any report which will be of value in the mining world can be made, the outcrops which are known must have some considerable amount of work expended upon them. The character of the ore varies a good deal, from a coarsely crystalline mineral to a dull almost amorphous form, and the percentage is also somewhat variable.

Seeing that ore containing less than 50 per cent. of chromic acid will not meet with a ready sale in the English market, it would be ill advised to ship any of the poorer classes of ore; but the ready means by which many of the inferior samples can be dressed to a fair percentage makes it advisable that all of these should be saved, since, even if it would not pay to bag the dressed ore and ship it to England, a time may arrive when bichromate works could be advantageously started in Nelson, when all these ores would meet with a ready sale.

I forward herewith various samples of the chrome ores which have been collected for the purpose of being analyzed.

CHROME DEPOSITS OF NELSON.

SUPPLEMENTARY REPORT BY S. HERBERT COX.

3rd March, 1881.

I HAVE the honor to inform you that, since I forwarded my former report on the chrome deposits of the Nelson Province, I have made a further examination of the Maungatapu, Dun Mountain, and Roding River districts, in which Dr. Irvine is sanguine of obtaining better results than from those places which I had previously examined.

Mr. Sullivan was sent by Dr. Irvine to accompany me and show me the various outcrops which he considered of importance, and I am bound to say that some very well-defined deposits of ore occur, which promise to be of considerable value.

Mr. Sullivan further informs that, in addition to the outcrops which he showed me, there were several others in the district; and Mr. Hacket also mentions the occurrence of reefs in the vicinity of the Miner River, but, as there was no desire on either hand to show me these, I have not seen them, and can give no report thereon.

Maungatapu Lease.

Near the trig. station on the Maungatapu Lease, a reef of an inferior chrome ore occurs, striking north and south. This has been cut by trenches at three points, but there has not been sufficient work done to show the width of the reef. It varies a good deal in character, even in the short distance it has been exposed, being at times of fair quality but associated with a great deal of black serpentine, while at others it consists of a much poorer class of ore.

Further up the hill, boulders of a superior chrome ore have been found, but as the reef has not yet been discovered I did not visit them; I however saw specimens, and, if the reef could be found, I should consider that a valuable deposit of ore might be expected.

Dun Mountain Lease.

At the back of the manager's house, and on the fall to the Pelorus Valley, chrome ore has been found at three or four points, following a north-and-south line, the most northerly outcrop consisting of dunite with chrome, while the others appear slightly better, but of a soft brown nature.

The work which has been expended on these outcrops is not sufficient to give any definite information concerning their extent, but their quality is not sufficiently good to offer much inducement to spend money on them at present.

I mentioned in my previous report the occurrence of some crystalline chrome ore below the Dun Mountain tramway, at an altitude of 2,500 feet, but stated that the outcrop which was

shown me was not sufficient for any conclusion to be drawn as to its probable extent. I have since been shown more of this, and am now able to state that in all probability it has a good run, as it can be traced by large boulders from above the stables, the outcrop mentioned above, for some distance, until in the low-lying ground towards the Duck Pond a reef 2 feet wide is seen. The ore appears to be very good, and is likely to prove continuous; it was known of in the time of the Dun Mountain Company, and it was to work this that the branch-line of tramway was proposed. It was opened on at several points, the old drives having now fallen in, but was never worked in consequence of the company ceasing to exist.

To the westward of this, an outcrop was shown me, which Mr. Sullivan calls "Brissenden's Reef," the same one that I mentioned in my former report, but Dr. Irvine is disposed to question this being the outcrop which he was anxious for me to see. It consists, as I before mentioned, of a mixture of olivine and chrome, and is about 10 feet in width; having, however, some richer patches of the ore in it. I do not think that for the present purpose this reef deserves attention, but in the event of workings being started it may be worth while prospecting.

To the eastward of the crystalline reef another series of boulders occurs, between it and the brown chrome reef previously mentioned, on the fall to the Pelorus Valley, so that it is probable that ore bands may yet be found there.

A narrow lead is also said to occur to the westward of Brissenden's Reef, and to run to the Duck Pond, but this I am unable to answer for, as no proof of it can be seen.

Roding River Lease.

In this ground a wide reef 15 feet across occurs, striking about north and south, and consisting mainly of dunite, in which the chrome at times greatly predominates. The ore which is stacked on the surface from this reef is not of the best quality, and will not, I am inclined to think, prove to be of the requisite standard of purity for it all to be shipped. As however this has been proved in a vertical direction for 300 or 400 feet, and some parts of it are far better in quality than the general mass, it is quite possible that the ore will improve. It resembles that from Brissenden's Reef, but is of slightly better quality.

On the western side of this reef, and between it and the copper drive, a fine crystalline reef of chrome ore occurs, but nothing has been done to prove it. The whole of the fall of the hill down towards the stream which drains this country into the Roding River has numerous patches of chrome ore, chiefly as boulders, but there is very little doubt that other valuable chrome reefs do occur in this direction.

Irvine and Tatton's Lease.

This ground adjoins that of the Roding River Company, and in it the best-looking reef which I have seen in this part occurs. It consists of a fine-grained compact black chrome which is over 6 feet wide, and is exposed, standing above the surface, for a distance of over 30 feet. If this ore could be brought to the market at a reasonable rate I should anticipate that the mine could be worked to considerable advantage; and it appears that this outcrop and the one previously mentioned at Ben Nevis are the most promising ones from which chrome ore could be extracted. With regard to the difficulties of transport, they are, I am afraid, rather great, as on the smallest estimate the cartage of ore to Hope Railway-station, by way of Stratford's, would not be less than eleven miles, five miles of which would have to be made, and this five miles would probably prove a good deal longer when the road came to be laid out. As however a cart road would be quite practicable to this point, and would moreover serve as a means of egress for the Roding River ore, and also, to a certain extent, for the chrome deposits of the Miner River, it has some advantages over Mr. Hacket's lease at Ben Nevis.

Briefly, I consider that the chrome deposits on Messrs. Tatton and Irvine's ground, those at Little Ben Nevis, under lease to Mr. Hacket, and the crystalline reef on the Dun Mountain property, now owned by Mr. Newport, are the best-looking deposits of chrome ore in the district, and I should recommend samples being shipped from these. As, however, the expenses of cartage will be great in each of these cases, and I further understand that the freight to England will not be less than 15s. per ton, I am inclined to think that it would be more remunerative to manufacture bichromate of potash in the district, and would suggest that, should works be started, it would be desirable to place these in a position which would be central to the greater number of chrome deposits, and at the same time near the railway. The natural means of egress for those chrome deposits which I have mentioned would be down the Aniseed Valley, and this would meet the ore from Little Ben Nevis as it was brought down the Wairoa Gorge. Of course important reefs may yet be found in the Dun Mountain and Maungatapu leases, which would make it necessary to modify this suggestion, but, from what can at present be seen, I am inclined to favour the above arrangement, although it would involve a somewhat considerable first outlay.

ANISEED VALLEY COMPANY'S COPPER MINE.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

I WAS instructed to specially examine and report upon this mine, as it was hoped by the shareholders that they had at length

discovered a payable copper lode, and I have paid two visits in order to see what had been done.

The first trip was on Saturday, December 18th, by which time the directors hoped that the mine would be drained; but when I arrived I found no less than 20 feet of water at the bottom, and no ore visible beyond a thin band at one corner of the shaft. I then arranged to pay another visit on the following Friday, as the men were perfectly certain they could get the water under by then; but when I arrived I found that there was yet 10 feet to be drawn, at which, seeing that the mine only makes about 4 feet of water in the twenty-four hours, I was somewhat disappointed.

I find that, since I examined this locality last year, an inclined shaft has been sunk at an angle of 60 degrees to a depth of 90 feet on what is considered to be the lode, and that in the lower 20 feet of this shaft copper ore has been found.

It will perhaps be better to describe the way in which the ore occurs throughout this mine, as I am by no means certain that any lode exists at all.

At the surface a narrow belt of ore was found many years ago, and some of it extracted: subsequently a drive was put in on the side of the hill, which struck this band at a depth of 45 feet below the original outcrop. A short drive was then made along the course of a back, or, rather, between two backs in the rock which constitutes what is called the lode, and then a shallow shaft was sunk for about 10 feet. At this point a little copper was again taken out; and then, after the so-called hanging-wall of the lode was broken through, another patch of ore was found beyond it. This was the state of the mine when I visited it last year, and since then the shaft I have alluded to has been sunk to a depth of 90 feet, the hanging-wall being preserved the whole of the way down, while the foot-wall is not to be seen, but so far as I can learn only indications of copper or green-coloured rock were met with until the lower 20 feet of the shaft was reached, when copper glance, cuprite, and native copper made their appearance, and elvanite also came in on the foot-wall side of the supposed lode. A very rich specimen appears to have been taken out of this elvanite, and forwarded to Melbourne, but owing to the water in the shaft I was unable to form a just opinion concerning the deposit. As, however, there was no doubt that ore was present, and I am assured that at the bottom of the shaft it looks better than where I saw it, I should imagine that for the limited amount that can be seen the indications must be good. The fact that 20 feet of ore has been passed through in the shaft is not sufficient to prove the mine a payable concern, and before any definite opinion can be formed a drive will have to be put in along the strike of the ore, both north and south, in order to see if it is of any extent, and not a merely local patch similar to what has been met with in the

higher levels. There has been some talk of entering a drive from a lower level to drain the mine before doing this; but as, if this drive be entered from the terrace above the river, it will have to be over 200 feet in length, and will then only drain the mine to about the level of the bottom of the present shaft,—while, if the drive is entered from the river-bank, thus gaining some feet in depth, the length will be increased to about 250 feet,—I do not think it will be well to undertake the work until more has been proved at the bottom of the shaft. I wish, however, clearly to express my opinion that the indications are sufficiently satisfactory to induce shareholders to spend enough money to prove what is really the extent of the patch of ore they are on; and if it is small the expense of doing this will also be small, while, if the deposit prove of any extent, it will repay the work itself.

ANISEED VALLEY COPPER MINE.

SUPPLEMENTARY REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

3rd March, 1881.

I HAVE the honor to inform you that I took the occasion of my return through Nelson to pay another visit to the Aniseed Valley Company's copper mine, as it had at this time been emptied, and when I arrived the first shot had been fired at the bottom of the shaft.

I find that the deposit of copper ore is by no means so good as I had been led to expect, and that, although ore may be seen in the shaft for the last 20 feet in depth, this ore does not occupy the whole of the so-called lode, but only occurs in strings a few inches in width; and at the bottom of the shaft I was only able to see one band of ore near the hanging-wall, the rest appearing barren with the exception of the patch from which the rich specimen mentioned in my former report was taken, and no more of this is at present visible. A band of ore showed in the face after the shot had been fired, and a good deal of water was coming in, so it is possibly opening out to a more defined deposit.

I hardly know what to recommend concerning this mine, for it is in the hands of just a few shareholders who have each subscribed a small amount of capital, all of which, I believe, has been expended. It is quite impossible to prove a mine of this description by spending a few hundred pounds in a haphazard way, and, except from a speculative point of view, there is not sufficient inducement to bring a large capital into the mine. Without a large capital, however, it is simply throwing good money after bad to attempt to work it, as all the expenses are increased in great proportion, and the money always appears to fail, short of having proved the mine.

THE RICHMOND HILL SILVER MINE.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

3rd March, 1881.

THIS mine has recently been abandoned by the original company, who found they were unable, with the capital in hand, to thoroughly prove its capabilities, and it has now passed to the hands of Mr. Hacket, at whose request I have been instructed to furnish a report reviewing the position of the mine. As at present it is impossible to get down the shaft in consequence of the water, I can only summarize the former reports by Dr. Hector and myself, and state what can be seen on the surface.

The lode, as first discovered, occurred cropping out in the bed of the Parapara River, immediately below a gorge formed in hard gneissic rocks which pass farther to the eastward into an irregular belt of steatite, while to the westward it passes into slates and limestones. These rocks rise to form the rugged mountainous country which surrounds the course of the Parapara, striking north and south, and standing almost vertical, with, however, a slight dip to the eastward, the lode itself corresponding in strike with the rocks and also underlying slightly to the east.

The width of the lode where first discovered was about 2 feet, and consisted of decomposed micaceous rock, with a band of the rich fahlerz about 4 inches in width; and, as this outcrop was sunk upon in the No. 2 shaft, the lode was carried to a depth of 20 feet, the bottom of the shaft, with strings of ore from 3 inches to 7 inches in thickness, and yielding on assay from 21 oz. to 1,700 oz. of silver to the ton.

The main shaft was sunk at a point about 40 feet S. 20° E. of the original outcrop on the lode, no rich ore being met with till a depth of 56 feet was reached, where a further deposit was found, and 5 tons were taken out, yielding from 40 oz. to 300 oz. per ton, and drives were continued to the northward on the course of the lode without proving it to contain any more of the rich ore, and moreover passing below the small No. 2 shaft last mentioned.

About the 56-feet level, the lode, which had hitherto been traced all the way in the shaft, passed out of it to the eastward, and the shaft was carried down for another 50 feet vertical, and then a short cross-course was put in intersecting the lode at a few feet. At this point the lode was well defined, and had widened out to about 5 feet, to the northward being split by a horse. Thirty-five feet only were driven at this level, 23 feet being to the north and 12 feet to the south, the ore in these drives yielding from 22 oz. to 51 oz. of silver per ton.

A few feet were sunk as a sump at the bottom of the shaft, and from this ore yielding from 85 oz. to 110 oz. silver was obtained.

This, then, represents the whole of the work which was done on the lode itself, but besides this some cross-cuts were driven at the 56-feet level to intersect parallel lodes in the vicinity, one of these being cut to the eastward, but not carrying any metal.

Several parallel lodes have been found on the surface, and in one of these, which consists of pyrrhotine, 2·98 per cent. of nickel was shown to exist.

Dr. Hector, in his report on this mine, 10th January, 1878, says, "I am inclined to hold for the present that the rich shoot carrying the cupreous silver ore dips at less than 1 in 1 to the south, and that it is underlaid by the argentiferous galena, which again passes into iron pyrites;" and the work which has been done appears to bear out this theory as far as the upper shoot of ore is concerned. Seeing, however, that the lode from the 56-feet level to the 106-feet level is utterly unknown, and that also south of the shaft no work at all has been carried on, it yet remains to be shown that there is not more than one shoot, more especially as in the No. 2 shaft the "fahlerz" or "richmondite" changed to an argentiferous galena, and then below this again the richest specimens of fahlerz found in the mine occurred.

The original company which was started to work this mine has, as I before stated, ceased to exist; but it is to be hoped that a mine having such a rich ore will not be allowed to stand idle. The principal difficulties which the former company had to contend with were the hardness of the ground and patchy nature of the ore; but when it is considered that the whole of the sinking and driving was performed by means of hand-drills, &c., I think it will be apparent that the first difficulty could be overcome. With regard to the patchy nature of the ore, nothing else could be anticipated, as it is hardly to be expected that a continuous shoot of ore, carrying the extraordinary quantity of silver which the assays show, would be found on the surface.

To the southward of the outcrop of ore a very large quartz reef, which appears to be striking about N.E., occurs, with thin veins of galena and pyrites, and it is probable that where these junction a rich patch may be found; but this can only be proved by driving.

The expenses of getting into the mine would not, I think, be very great. The water-race, which is out of repair, would probably be set to rights for about £100, and the water-wheel and pumps, which are still in the mine, appear to be in good order. I am informed that with the present pumps it only takes about three days to empty the mine, and that it requires very little pumping afterwards to keep it dry, so that the available water-power could be used to advantage for compressing air to drive one of the rock-boring machines which are now used at the Thames and Coromandel with such success.

I append a complete list of all assays of this ore which have

been made by the Geological Department, and may state that the matrix of the lode is one in which the richer silver ores might be expected to occur, from experience gained in other parts of the world.

ANALYSIS AND ASSAYS OF THE RICHMOND HILL SILVER ORE MADE AT THE COLONIAL MUSEUM, WELLINGTON.

Analysis.

	Percentage.
Sulphide of lead	36·12
Antimony	22·20
Bismuth	Traces
Copper	19·31
Iron	13·59
Zinc	5·87
Silver	2·39
Manganese	·52
	100·00

Assays for Silver.

Lab. No.	Nature of Specimen.	Per ton. Oz.	dwt.	gr.
1692	—Richmondite	185	0	0
1738	„	190	0	0
1750	„	331	0	0
1805	„	596	0	0
1835 (1)	„	77	8	3
„ (2)	„	76	13	21
„ (3)	„	78	19	2
„ (4)	„	522	1	6
1888 (*a*)	—(56-feet drive)	82	18	15
„ (*b*)	„	284	2	3
1892 (1)	.. ..	32	15	0
„ (2)	.. ..	37	15	11
1935	.. ..	507	4	0
1939	—Richmondite	626	0	0
1943	„ (impure) ..	90	11	19
1961 (1)	—Mica-schist	Traces		
„ (2)	—Richmondite	412	7	20
„ (5)	—Galena	51	5	19
„ (7)	—Gangue of ore	23	12	15
„ (9)	—Richmondite	600	11	22
„ (10)	„	289	3	13
„ (11)	—Galena with much gangue	21	2	11
„ (12)	—Galena, fine-grained ..	163	9	0
„ (13)	—Richmondite	1,792	17	16
„ (16)	—Galena	23	2	16

Assays for Silver—continued.

Lab. No.	Nature of Specimen.	Per ton. Oz.	dwt.	gr.
1998	(1)—Richmondite	13	13	4
„	(2) „	11	2	9
2023	„	201	3	8
2038	„	45	0	0
2068	(1) „	98	0	16
„	(2) „	82	18	5
„	(3) „	52	15	9
„	(4) „	279	3	3
2094	(1) „	110	11	6
„	(2) „	94	10	23
2095	„	85	9	22
2113	„	87	12	6
2336	„	2	10	8
2346	„	8	5	3

Before closing this report I wish to point out that, in the event of a fresh company being formed to float this mine, I consider it useless to commence operations with a less paid-up capital than £10,000; and the larger the nominal capital is, the better. In making this statement my reasons are that, before any money can be made from the mine, it wants to be thoroughly proved, as the expense of transport of the ore would be too great to make it advisable to send it away, when it could readily be smelted on the ground. Under these circumstances the first outlay would have to be somewhat large, in order to prove beyond doubt that there was sufficient ore to pay for the erection of smelting-works; and the sooner this could be shown the better for all parties concerned. In the meantime, I consider that the indications are exceptionally favourable, and the property should prove a very valuable one.

WALLSEND COLLIERY, COLLINGWOOD.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

3rd March, 1881.

I HAVE the honor to inform you that, in accordance with a request from Mr. Guinness, authorized by you, I have made an examination of part of the Wallsend Colliery, Collingwood, in order to see whether the work proposed, to cut the No. 2 seam of coal by an intermediate level, was the best which could be arranged, and have come to the conclusion that it could not be improved, when the question of cost is taken into consideration. In the old workings, which were at a higher lever than the present ones, the No. 2 seam was, I am informed by Mr. Marshall, of good quality, and of sufficient thickness to be profitably worked to the north and east of the drive, while to the south and west it was found to thin out

considerably and to be much mixed with shale. In the lower tunnel the No. 3 seam, which appears to be of better quality to the south and west, is the one which has been worked.

This lower tunnel, which is the one I examined, has been driven for a distance of 840 feet, rising slightly towards the end. A fault running slightly west of north was cut at 92 feet; and at 598 feet in, beyond the workings in No. 3 seam, an uprise was made, cutting an intermediate seam of coal, which is also met with in the tunnel, at 20 feet; it was continued to 90 feet, and at 35 feet above the lower seam cut the No. 2 seam.

The No. 2 seam is also cut at the end of the tunnel, but here it is very thin, and in the uprise it is about 20 inches thick, but of very inferior quality.

A return incline-drive was put in at 143 feet past the uprise, and on the intermediate seam of coal, which followed the coal back to the uprise shaft. From this point a prospecting drive which had previously been entered from the uprise shaft has been heightened for a distance of 115 feet, and about 25 feet has been driven from there.

As before stated, the fault runs slightly west of north, and as the drive is being taken it should cut the fault at 170 to 200 feet, when a drive could be started to intersect No. 2 seam, and would thus cut it in the area in which it has hitherto been a payable seam of coal. As moreover this drive has hitherto been carried on in the coal, it will, more or less, pay its way, and, if a drive were put in from the end of the tunnel to intersect No. 2 seam, a distance of not less than 900 feet would have to be driven to attain the same point. It follows that the system proposed by the manager is the better of the two, and I cannot see that it can be improved upon, supposing the character of the coal to hold, as the present indications would lead one to believe.

NORTH AUCKLAND DISTRICT, INCLUDING THAMES, COROMANDEL, ISLAND OF KAWAU, AND DRURY COAL FIELD.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT-GEOLOGIST.

MEMORANDUM OF INSTRUCTIONS BY DR. HECTOR.

14th August, 1880.

I WISH you to proceed to Auckland with the view of continuing your survey of the Kaipara District so as to connect it with the previous reconnaissance survey of the Waikato Basin. The following points are to be attended to:—

1. Follow the section of the Waitemata series to its eastern base, where it forms a junction with the Palæozoic formation east

of Tamaki. Determine if the Parnell grit-bed overlies the Orakei Bay fossiliferous marls, and whether it corresponds to the horizon of the Cape Rodney beds, which appear to be at the base of the Waitemata series further north.

2. Revise the section showing the relation of the Cape Rodney beds to the sandstones of the Pakiri Range and the Great Omaha.

3. Revise the section from Mr. Rye's station on the Otamatea eastwards to Bream Tail and westwards to Komiti Point.

4. Revise the section along the north shore of the Manukau Harbour, in order to determine the relation of the outcrop of the Mercer marls to the upper Waitemata beds and the trachydolerite series of Manukau Heads.

5. Revise the section at Captain Colbeck's above Pahi, and determine the relations of the Mount Brown limestones there to the greensands.

6. Visit Coromandel, and examine the relations of the Matawai coal-beds to the Patawau slates, and to the auriferous greenstone-trachytes, and tertiary trachyte series of Beeson's Island.

7. Visit the Shortland District from Tararu Creek south to Ohinemuri.

8. Map the district between the south branch of the Manukau Harbour and Mercer, including the Drury Coal Field and eastward into the old rocks of the Miranda Ranges.

9. Report on the results of Mr. Hunt's boring operations at Mercer.

REPORT.

Wellington, 22nd November, 1880.

I HAVE the honor to inform you that, in accordance with your instructions dated 14th August, 1880, herewith appended, I have examined the various sections mentioned with the exception of the one between Auckland and Maraetai, where the Waitemata beds rest upon the slates, this work having been delayed from time to time in consequence of unsuitable winds prevailing while I was in town, and it was subsequently left because my presence in Wellington was necessary. I have, I conceive, acquired sufficient evidence to place the relative position of the Cape Rodney and Waitemata beds beyond doubt, and it now remains to settle by the fossils what their absolute position in the sequence may be. To me it appears that these fossiliferous beds probably correspond with the Whangarei limestone, as I shall attempt to show in the body of the report, in which case the whole of the Waitemata series would have to represent a great expansion of our Eocene beds, seeing that they are closed by the trachydolerite breccias of the Manukau Heads, which cannot be younger than the very lowest Miocene strata. This position of the breccias cannot be demonstrated in the district under examination, as no beds occur here

overlying them; but, as you have shown, evidence is not wanting elsewhere to prove that the beds of Miocene age were deposited during a time of volcanic rest, and beds, which strongly resemble in character these breccia beds, are overlaid at Hicks Bay, near the East Cape, by fossiliferous beds of probably Miocene age.

I need not, I think, further refer to general questions here, as my report will treat of all the points which were observed, and all the evidence which will be required will, I think, be found in the district under immediate consideration.

I also visited the Island of Kawau, in accordance with telegraphic instructions received while in Auckland.

Narrative.

I left Wellington for Auckland on the 12th September, arriving there on the 14th, and left again for Mahurangi on the 16th, devoting the intermediate time to the study of the beds round the Auckland Harbour as far as Orakei Bay. On the 17th I examined the beds around Mahurangi, in which it was reported that coal had been discovered; on the 18th I started on a trip through Little Omaha, Mangawhai, to Bream Tail, and thence across to Curtis's Point, on the Kaipara Harbour, returning to Mahurangi by way of Mr. Rye's and Wellsford. This work found me employment until Monday, September 27th, when I returned to Auckland, where I remained until Saturday, October 2nd, examining the beds towards Tamaki, and also tracing the outcrop of the Parnell grit and its relation to the Orakei Bay fossiliferous strata. On Saturday, October 2nd, I left Auckland for the Thames, where I remained until October 9th, examining the country from Tararua Creek to Ohinemuri; after which I returned to Auckland, and proceeded to Kawau on the 12th, where I was employed until the 20th, on which day I returned to Auckland, and took my departure for Coromandel on the 22nd. Here I devoted my attention to the points mentioned in my instructions, and also visited the coal outcrop at Cabbage Bay, returning to Auckland on the 28th; and from then until November 2nd I spent the time in walking over the ground between Auckland and Mercer, and examining the coal measures of the Drury and the beds around Mr. Hunt's borehole. On the 3rd November I left for the Kaipara, reaching Captain Colbeck's on the evening of the 4th, and from that date until November 10th I was employed in revising my sections of the Pahi and Komiti Point. I returned to Auckland on the 10th, and sailed for Wellington on the 11th, arriving here on the 14th November.

Report.

It will be necessary to divide my report under different heads, since the country which I have been over this time is by no means

continuous, and, generally speaking, the work at one part has but little bearing on that at another part.

MAHURANGI AND KAIPARA DISTRICT.

It will be seen, by reference to my last year's report on this district, that I subdivided the beds which are represented there in the following manner :—

I. Recent and Pleistocene	1.	Brown sands.
	2.	River silts.
	3.	Consolidated sands with lignite.
II. Pliocene ..	4.	Scoria, lava streams, and craters.
IV. Lower Miocene..	5.	Trachydolerite breccias.
	6.	Trachyte sands and concretionary greensands.
	7.	Sandy marls (plants and fossils).
		Grits and slate-breccias (fossils).
V. Upper Eocene ..	8.	Limestone and grit.
VI. Cretaceo-Tertiary	9.	Chalk-marls with flints.
		Limestone (hydraulic).
		Firestone.
	10.	Calcareous greensands (glauconitic).
		Limestone, in flakes, and cornstones.
		Dark greensand and red sandstone.
		Coal.
VII. Lower Greensand	11.	Quartz sandstone (micaceous) with *Inoceramus*.
XIIB. Upper Devonian	12.	Slates and aphanite.
	13.	Dykes, bosses, and trachytic flöes of uncertain age.

Since a large portion of my last year's report is devoted to the description of the boundaries of these different formations, it will be unnecessary for me to go over that work again, as, with very few exceptions, I see no reason to alter my decisions respecting these. There are, however, one or two cases in which changes will have to be made, and these will be specified in detail.

As far as the sequence is concerned, I am now more than ever convinced of its correctness; but it is by no means improbable that the series of beds to which Lower Miocene age was assigned last year are in reality Eocene; but, as this can only be settled by the fossils, aided by the facts which I have cited in the introduction to this report, I shall leave that question entirely out of consideration, since it does not affect my work at all.

Firstly, then, as regards the sequence. I have no further notes to add regarding the slates, which take but an unimportant part in

the formation of the country under consideration until the ranges north of Mangawhai are reached. The boundaries assigned to the slates here are approximately correct; but the sandstones, &c., which flank these slates on the Mangawhai side, and which I last year referred provisionally to the Lower Greensand, prove on closer inspection to belong to Beds Nos. 6 and 7, the "concretionary sandstones and sandy marls." It is also probable that the beds between the Waipu Cove and Bream Tail, which I last year referred to the coal measures, also belong to this series.

Beyond these points I have really no changes to make in the classification of last year; but, at the same time, have a considerable number of notes to add with regard to the relations of the next series of beds, from the coal measures up to the trachydolerite breccias.

Lower Greensand Beds.

At the Falls, at Mahurangi, which is one of the places at which coal is supposed to have been discovered, there are beds of hard sandstone, separated by thin beds of marl, in which broken remains of plants and very small pockets of coal occur. These beds are striking east and west, and dipping south at very high angles. They can be traced for a short distance down the harbour, below the point where Mr. Palmer's old lime-kiln stands, and occur again in the bed of the creek from which the steamer water-supply is derived, where they are striking E.N.E., and dipping S.S.E., still at very high angles.

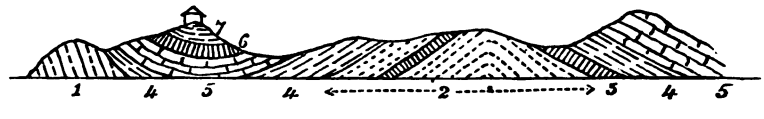
At an intermediate point in the bed of a creek the strike appeared to be north and south, but here correct observations were somewhat more difficult to gain. At places these sandstones assume a thorough cannon-ball character, and, in many respects, bear a close resemblance to the Mataura beds, to which they may possibly belong.

Cretaceo-Tertiary Series.

Resting on the above beds, certain marly limestones occur, resembling at their base the hydraulic limestones of Wilson's, but of an inferior character. They pass up into beds of hard glauconitic limestone, and, overlying these, beds of marl come in; the general dip of these beds is west at an angle of 10°. The marly limestones mentioned occur for a few chains up the creek, when beds of hard banded sandstone and dark-blue limestone come in, with shales dipping S.W. at an angle of 30°, and passing below them. A bed of stone which much resembles the Matakana firestone also occurs near the junction of these rocks.

Farther up the creek again the beds are striking N. 55° W. and dipping northerly; sandstones and hard glauconitic limestones occurring. About this point the limestone was formerly quarried

for burning, and a glauconitic limestone occurrs under different conditions from any that I have seen elsewhere in the district—viz., similar to the hydraulic limestone as regards appearance, but with the mineralogical characters of the hard banded limestone farther down the creek. These beds pass insensibly into the true marly limestones, and from this horizon fossils are reported to have been got, but the accounts are so mythical that no dependence can be placed upon them, and I was unable to obtain any myself. A considerable thickness of these beds now occurs, and they can be traced continuously through the low grounds to the foot of the hills over which the Port Albert Road crosses. The following section will serve to elucidate the above description :—



Section up Palmer's Creek. 1. Plant and cannon-ball sandstone. 2. Sandstone and hard blue limestone. 3. Glauconitic limestone. 4. Inferior hydraulic limestone. 5. Marly limestone. 6. Glauconitic limestone. 7. Marls.

Down the Mahurangi Harbour, where Mr. Wilson is burning his hydraulic limestone, the same beds occur as a syncline precisely as I showed them in my last year's report. The lower part of these beds is very inferior in character, and Mr. Wilson informs me that he is unable to burn it for the manufacture of cement; but the higher beds are more satisfactory, and it is these that he is using. They are all standing at high angles, being underlaid by greensandstone, and at the other quarry a bed of greensand is seen interstratified with the limestone.

A similar section of these rocks occurs at Mr. Rye's station, on the Otamatea, and again at the Pahi township it is reproduced, but at neither of these localities is the sequence so clear as in Palmer's Creek. At Pahi lower beds occur, as mentioned last year, the fossils of the coal measures having been obtained; and I was given a piece of coal by Mr. Rye, which had been got out of some drift near this place, of which the following is the analysis :—

Fixed carbon	55·89
Hydrocarbon	35·29
Water	2·94
Ash	5·88
	100·00

The coke of this coal cakes and puffs very much, and it would be a very valuable coal could the seam be found.

OLDER TERTIARY BEDS.

5. *Trachydolerite breccias.*
6. *Trachyte sands and concretionary sandstones.*
7. { *Sandy marls* (*plants*).
   { *Grits and slate-breccias* (*fossils*).
8. *Limestone and grit.*

These beds last year were divided into Lower Miocene and Upper Eocene; but, for reasons set forth above, it will be better to consider them all together, reserving the determination of their age for the present.

The first section which it is necessary for me to call attention to is the one which is exposed at Tokatapu (Captain Colbeck's), above Pahi, in the Kaipara Harbour.

Along the banks of the harbour, immediately opposite Captain Colbeck's landing, the beds consist of alternations of sandstone and marl, dipping S.W. at an angle of 60°; and associated with the lower beds of these a band of limestone is seen, below which again more marls crop out, and then the main bed of the limestone occurs standing at high angles, being vertical at the "Gibraltar Rocks." Further on these limestones are cut out by the Mahurangi limestones and chalk-marls, on which the greensand marls rest unconformably as mentioned last year; and it is probable that the limestone of Gibraltar Rocks would also occur at the base of these beds, although I was unable to satisfy myself on this point. In the hills between the Pahi arm and Paparoa this limestone covers a good deal of country, and is better seen on Skelton's Hill than elsewhere, although even at this place no connection with the other beds can be traced, and the section I have cited above is all that can be depended upon in this locality. This limestone is, in all probability, the same as the Whangarei limestone, to which it entirely corresponds in character, being glauconitic in places, and in its purer parts consisting of fine crystalline limestone. There are a number of corals associated with it which resemble those brought from the breccia beds of Little Omaha last year; but it appears to be utterly devoid of other fossils.

At Komiti Point, again, a gritty bed occurs at the base of this series, resting quite unconformably upon the upturned edges of the chalk-marls; and it was from the lowest beds of this series that my collection of fossils was made last year. After passing round the first point and reaching a small bay beyond, a second fossiliferous bed comes in, which is about 100 feet higher in the vertical sequence than the fossiliferous bed first mentioned. This bed corresponds entirely with the fossiliferous deposit at Orakei Bay, Auckland, containing the same fossils, and being of precisely the same character; and these beds pass up again into regularly stratified sandstones and marls, which continue until just before

the far point is reached, where beds of consolidated sand come in, with lignitiferous deposits and old timber partially carbonized. The following section shows the relations of these beds :—

Section at Komiti Point. 1. Chalk-marls and hydraulic limestone. 2. Fossiliferous beds (grit). 3. Incoherent sandstones. 4. Fossiliferous beds (Orakei Bay). 5. Banded marls and sandstones. 6. Consolidated sands.

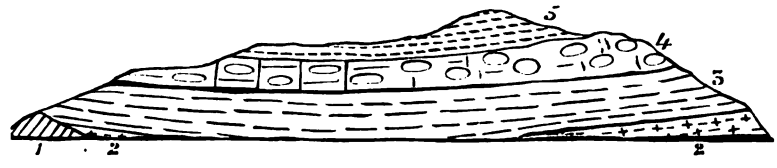
The banded marls and sands in their higher beds have a concretionary character, and correspond to the concretionary sandstones which occur elsewhere. In the Beds No. 2, and also higher in the series, I found numbers of broken plants, although none of these were sufficiently well preserved to be identified.

Reverting now to Mahurangi, we here find that on the upturned edges of the chalk-marls and hydraulic limestones, resting as nearly horizontally as possible, a series of hard sandstones and dark-grey marlstones occur, in which broken remains of plants and small pieces of coal are very plentiful; and these small pieces of coal, none of which are more than 3 inches and few more than ½ inch in thickness, are all that have as yet been discovered to warrant the assumption that a coal-seam occurs in the neighbourhood. The Rev. Mr. McKinney, who appears to have interested himself considerably about these beds, accompanied me to the various places where work had been undertaken, and showed me a large number of specimens which had been collected, amongst which were some decomposed specimens of sandstone, through which the infiltrating water had deposited a black substance, probably iron and organic matter, in films, and these he informs me are the specimens which Mr. Moody stated were outcrop coal.

Around Mahurangi the concretionary sandstones are not exposed, possibly because there are no road-cuttings through them there, for on the road-line from that place to Port Albert the concretionary structure is well developed in numerous beds interstratified with sandstones with plants. On the low hill which the track crosses between Matakana and Whangateau most characteristic beds of concretionary sandstone are met with, which overlie similar marly beds, and I do not think that my determination of last year in placing the Matakana marls below these was wrong. These concretionary sandstones are not so well seen at any point before this: indeed, the large concretions are not apparent around Mahurangi, as I mentioned before. They weather to precisely the same character of rock —a deep red sandstone traversed by veins of a black substance

—as the Mahurangi beds; but they further exhibit in a marked degree the most beautiful concretionary character that I have seen. These concretions are shown in the road-cuttings, and are marked in the decomposed rocks by numerous concentric rings which shade off into the transverse and vertical joints previously mentioned. This character of rock continues until we descend to the Whangateau Harbour, where the section is obscured during the descent; but at the base the slates crop out and extend pretty well round the harbour, and until Little Omaha is reached but little can be seen.

At Little Omaha the following section is exposed on the north side of the bay into which the Koheroa falls, and demonstrates in a most convincing manner the passage of the fossiliferous breccias and grits up to the first bed of the concretionary sandstones :—



Section at Little Omaha. 1. Slates. 2. Sandstone grit and breccias. 3. Black marls and marly greensand. 4. Concretionary sandstone. 5. Bedded sandstone.

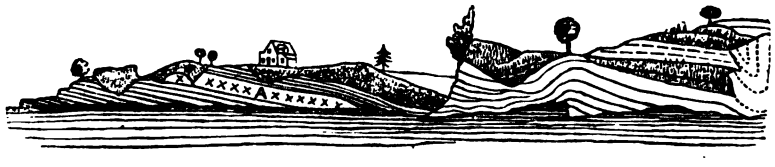
Coming round the coast from the Little Omaha Harbour until nearly reaching the Koheroa Bay, slate occurs, but as we reach the small bay before the one into which the Koheroa falls slate-breccias appear lying unconformably upon the slates, and contain a few fossils. In the tideway a thin bed of sandstone is resting on the breccias and dipping seaward; another belt of slates succeeds these; and then a coarse gritty sandstone comes in, representing the breccias, overlaid by black marls, which are about 50 feet thick, and these are overlaid in direct sequence by the concretionary sandstone, as shown in the above section. The slates here occupy the foreshore, a sandy beach strewn with concretionary boulders from the cliffs occupying the intermediate position between them and the cliffs. As the point is turned the marls only are seen in the low cliff until they rest directly on a small bluff of slates; but in the foreground are beds of slate-breccia dipping below the marls which also form flat reefs there. A little further along the slate-breccia is very coarse, and contains some great blocks, as much as 7 feet through, with only small patches of sand with corals, &c., in between; and here we come to the Koheroa Bay. After passing across this and crossing the Koheroa Creek the breccias again appear, varying a great deal in their degrees of coarseness, and they are overlaid by black marls and dark marly greensands, these beds stretching round the coast until the slates once more

crop up. It is quite certain that at this point the rocks are not of the same character as at Mahurangi, where the coal-prospecting is being carried on; but the different characters are to be expected, because the beds were deposited under distinctly different circumstances, those around Mahurangi being estuarine, while at Little Omaha they are as clearly salt-water deposits, representing an adjacent shore-line and rough rocky coast. The subsequent subsidence which occurred when the marls and concretionary sandstones were being deposited here brought about uniform conditions throughout the district.

The slate-breccias and grits which occur at Little Omaha extend round Cape Rodney nearly as far as the mouth of the Pakiri River, and may also be seen in the beds of the smaller creeks which fall to the coast around Cape Rodney, the upturned slates forming the basement rock of the district. As the hill is ascended from Little Omaha it is not long before the concretionary sandstones are met with, weathering out in the road-cuttings, and these concretionary sandstones are the most noticeable beds until the summit is reached; there are, however, marly beds and regularly stratified sandstones to be seen, but their characters render them less conspicuous than the others, and no dependence could be placed on these in any correlations which were made with the Mahurangi beds. Fortunately, however, I am not compelled to place any dependence upon them at all, for on the summit of the hill Mr. Greenwood has cleared a considerable area of ground stretching down into a gully which flows towards the Pakiri, and a very fine natural section is thus exposed. This section shows a number of alternating beds of concretionary sandstone, flat-bedded sandstone, and marlstone, the two latter corresponding exactly with those beds at Mahurangi which have been prospected for coal, and containing as well numerous broken plants and small nests and patches of coal. These thin veins of coal are of frequent occurrence, and one of Mr. Greenwood's sons informed me that they could be found as low down as the beach at Pakiri, where, however, I did not observe them myself. All these beds are lying remarkably flat, but have a slight dip to the westward; they however undulate slightly throughout the ranges. There is therefore no doubt that the Mahurangi beds and these concretionary sandstones are the upper beds of the series of which the Cape Rodney fossiliferous series is the base, and their age must therefore be determined by the fossils from this horizon. Neither do I think that it is possible for the Waitemata beds to be other than the equivalents of these Mahurangi beds, for several reasons; the first of which is, that they correspond to them in mineral character, and have interstratified beds containing broken plants under precisely the same conditions as at Mahurangi and farther north. Secondly, the Waitemata beds round Auckland pass gradually up to the trachydolerite breccias of the Manukau Heads, for I saw

no reason during my trip to modify my section of last year; and, lastly, the sequence between Fort Britomart and Orakei Bay is sufficiently conclusive to make it a matter of certainty that no stratigraphical break occurs above the horizon of the Orakei Bay fossils, which are again seen at Komiti Point, as I have previously mentioned in this report.

It will be interesting to give the section from St. George's to Orakei Bay, as that shows clearly the position occupied by the Parnell grit, at which it was thought possible an unconformity might occur with regard to the Orakei Bay fossiliferous beds.



A. Parnell grits.

After passing round St. George's Bay from Auckland, instead of finding the flat-bedded strata of Fort Britomart, beds having a similar but more indurated character occur, striking N.N.E., and dipping E.S.E. at an angle of 35°. Associated with these beds, and occurring at almost the lowest visible horizon there, the Parnell grit occurs. At the Point these beds strike north and south, and dip east at an angle of 70°.

Farther on, before reaching the small bay before Orakei Bay, the rocks are dipping S.W. at an angle of 30°, a sharp series of contortions which occur giving rise to a somewhat peculiar section. In Judge's Bay the strike is back to north and south, and the dip is west at an angle of 20°. Below the Parnell grit, in its typical locality, come finely-alternated beds of marl and sandstone, looking for all the world like the Fort Britomart beds. There is, assuredly, no unconformity between these beds, and they remind me forcibly of those at Waiwera, where they are lying flat. At the entrance to Orakei Bay these sandstones and marly beds are striking N.N.W., and dipping W.S.W. at an angle of 20°, the strike carrying them along the coast to the head of the bay, and from their appearance here one could have no doubt that they are above the fossiliferous beds on the other side of the bay. The dip rises to 35° on the point, and from there to the head of the bay it flattens, and at Morrin's Point another outcrop of the fossiliferous beds appears, interstratified with marly beds with plants, and apparently passing below the last-mentioned beds conformably.

The fossiliferous beds at the best-known locality, near the east head of Orakei Bay, are lying nearly horizontal, and from

there for some distance towards Tamaki Head they preserve their horizontal bedding, so that, practically, they are nearly the lowest beds to be seen.

As I previously explained, I was prevented by various circumstances from examining the beds as far as Maraetai, where they appear to rest upon the slates, but, looking at them from the steamer going to the Thames, I am convinced that but few lower beds crop up in that distance.

As, then, it appears that the fossiliferous beds of Orakei Bay meet their equivalents in certain beds previously described at Komiti Point, and that these pass down to the best-known fossiliferous horizon there, these lower beds resting quite unconformably upon the chalk-marls in this district; and as again the characters and distribution of the higher part of this series correlate the plant sandstones and marls from Auckland north to Mangawai, I see no reason to consider that my last year's correlations were in any way incorrect; but, as I have shown, beds resembling the Whangarei limestone occur with the lower members of these beds near Captain Colbeck's, at Pahi, and, as again I shall show on the Island of Kawau, conglomerates which occur at the base of the series corresponding with the breccia beds of Little Omaha, and containing similar fossils, pass at places into limestones, which also resemble the Whangarei limestones in character—since, I say, this is the case, I think it by no means improbable that a slightly too high horizon has been assigned to these beds, and that in reality they belong to the Eocene formation, and not Lower Miocene as suggested last year.

ISLAND OF KAWAU.

I made a careful examination of this island in the course of my trip, finding that Dr. Hector's previous mapping was so accurate as to leave no work to be done in revising this, and I devoted my time to the examination of the relations of the fossiliferous and overlying beds on the one hand, and the relations of the slates, &c., with the copper and manganese lodes on the other, and I think some very interesting points are to be solved in connection with these.

On Little Kawau or Challenger Island, slates occur striking N.N.W. and dipping westerly, and these, occurring again on the mainland, stretch from there until nearly reaching Fossil Point. They crop out again at the head of the bay from beneath the Tertiary rocks, and after passing the narrow belt of fossiliferous rocks at Limestone Point we have an uninterrupted stretch of slates until reaching the copper mine, with the exception of one small outlying patch of conglomerate off the S.W. point.

At the copper mine the strike of the lode is E.N.E., and the underlie, which is slight, S.S.E., the jasperoid slates in which it

occurs appearing to strike N.N.E.; they are, however, very wavy, and are standing vertical.

I am informed that in the shallow levels of the mine the ore consisted entirely of pyrites, varying from a 16 per cent. copper ore to mere mundic. The lode was seldom less than 6 feet, and when the mine was abandoned no less than 15 feet thick, the compact yellow ore averaging 16 per cent. of copper lying against the pyrites. The water does not appear to have been very heavy, no difficulty having been experienced in keeping the mine dry. The pyrites appears to have been thrown away as useless in the old days, and the system of working was no doubt expensive for various reasons, a few of which may be cited. The shaft was sunk from the crown of a spur, and water pumped to this elevation, being there employed to drive a water-wheel. The ore was also drawn to the top of this shaft, and then tipped down one side of a spur, to be trucked through a drive to the other side, and thence shipped to the smelting-house, about four miles away. The fuel employed in smelting was wood, and this was purchased by weight. It will thus be seen that there was a considerable amount more handling of the ore than was by any means desirable: and, as far as the water-wheel is concerned, I am unable to understand the reason of its erection at all. Besides these, however, the development of the gold fields and the increased price of miners' wages, to say nothing of the litigation between the rival companies, no doubt assisted materially to close the mine; and the heaves or faults in the mine probably rendered it a matter of some difficulty to follow the lode. Of course at present the workings are filled with water, and no examination can be made underground.

The mine was first worked for manganese, and the copper lode was discovered accidentally in the course of work. It was then worked on a small scale for nearly two years before any pumping machinery was required. The best ore is reported to have been obtained from the outer shaft, under the sea.

The manganese ore here occurs under the same conditions as prevail throughout the colony—viz., as irregular masses or blows in the slate, not appearing to follow any distinct lines of fracture; and in the immediate vicinity of this a band of very ferruginous and at times compact gossan occurs, which would pass as a good iron ore: this gossan, however, forms the back of the copper lode, and varies a good deal in its character and quality.

Having now described the copper lode and associated rocks at the mine, at which place of course more information can be gained than elsewhere, let us now turn to another most interesting locality on the island, known as Manganese Point.

Lying off this point is a small island called Pembles Island, on which jasperoid slates occur, striking N.N.W. to N.W. and dipping westerly, and with these rocks small pockets of manganese occur. To the eastward of Pembles Island, and lying between there and

Manganese Point, rotten sandstones traversed by numerous joints appear. At Sharp Point banded slates and sandstones occur, striking N.N.W. and dipping westerly, and enclosed in these rocks are very hard blue concretionary-looking masses, which probably represent the rock which Dr. Hector has mentioned as possibly being a dyke.

These beds are much traversed by joints, and in the hills are greatly decomposed.

Along the beach from Sharp Point in the direction of Manganese Point, alternations of banded slate and hard sandstones traversed by numerous veins of iron occur. These rocks are sometimes, indeed often, intermingled, blocks of slate occurring in the sandstone and of the sandstone in the slate. At Manganese Point a belt of jasperoid slate occurs to the eastward of a large blow of manganese, these slates still following the N.N.W. course; and between this point and Pembles Island a belt of sandstone, mentioned as occurring in the reef, separates the two belts of jasperoid slate.

A reef of ironstone occurs on the point, but does not show *in situ* on the beach, being, however, represented by large boulders, the result of the degradation of the slate rocks: the reef probably lies to seaward of Manganese Point towards Pembles Island. After passing the bay next to Manganese Point the jasperoid slates again occur, and these can be followed to the north harbour, where from the first bay they cross to the opposite side of the harbour.

Mr. S. Thorne George has found copper ore below high-water mark in a bay lying to the eastward of this, the one in which the house stands; and again to the eastward jasperoid slates are seen forming the mass of Mount Taylor. It appears probable that this outcrop of copper ore marks a continuation of the iron lode of Manganese Point, which will, I think, in all probability change to some form of pyritous ore as it goes down, since it appears to be identical in character with the gossan associated with the lode at the copper mine.

These jasperoid slates in which the lodes occur strike right through the island, appearing again in Lewington's Gully, and at the waterfall a reef occurs, striking N.W. and S.E. This reef passes insensibly into the jasperoid slates, which are here very chertose owing to the manner in which they have been traversed by small quartz veins, and it appears from the number of analyses which have been made of specimens from various localities that nearly all these cherty slates carry a little gold. This gold is, as a rule, very impure, but is not contaminated as at the Thames with silver, but, as might have been expected, with copper, a metal which is largely represented on the island.

On the seaward side of the island a different class of slates occur, with which are associated certain serpentinous rocks. At a point from which the beacon bears E. 5° S. what appears to be a serpentinous dyke occurs, striking N.W. It consists of a decom-

posed gritty rock with included pieces of true serpentine, and might readily be accounted for as a diorite dyke which had suffered decomposition. It is coated on its weathered surfaces by a deposit of ferric oxide, and in strike corresponds with that of the slates, and also the reefs through the island. I think it is probable that this is the dyke which Dr. Hector shows striking east and west through the island; but, as recent slips have exposed it far better now than it could be seen even a few months ago, I feel confident that the N.W. strike is the correct one.

The slates in the vicinity bear a marked resemblance to the green slates of the Maitai series, but beds also come in which have their nearer equivalents in some of those slates in the Baton River which belong to the Te Anau series. I see no sign of the jasperoid slates over here, but the green slates carry a great deal of mundic, and also have some hard vesicular-looking bands with them.

Along the coast calcareous slates occur with veins of calcite running through them, and these I am inclined to think correspond with our Maitai limestone horizon. They have a marked resemblance to the calcareous slates which occur at the entrance to Croixelles Harbour close to where the serpentines come in, and the serpentinous character of the rocks in the immediate vicinity of the calcareous slates at Kawau adds further proof to the correlation. The dyke above mentioned would thus correspond with the serpentine belt.

If this be so, then the copper ore of Kawau Island occurs in the Maitai slates at no great distance above the serpentine belt, in much the position which I indicated as probable in my report on the Nelson District (Geological Reports, 1874–76, p. 8).

I must not fail to repeat here what Dr. Hector mentions in his report on Kawau—that at Emu Point indications of manganese and copper occur. This occurrence is specially interesting as no sign of the copper can be seen in the stone, but only traces of manganese and signs of the iron ore which I have mentioned before. When, however, this stone is tested chemically it shows the presence of 1·04 per cent. of copper.

Should the copper mine ever be reopened I have little doubt that the property would prove of considerable value, as, with a large lode, if the ore were only poor a profit should readily be made, more especially if the manufacture of sulphuric acid were combined with the extraction of copper.

Tertiary Rocks.

Resting unconformably upon the slates at two or three points along the southern side of the island, and occupying the greater part of the north-eastern side, a series of Tertiary rocks occur.

At Fossil Point conglomerates form the lowest beds of the series, and these pass upwards into grits with a few fossils. There

are traces of coal in this grit, about the same prospect of coal-seams being found here as at Mahurangi.

Overlying these beds of grit come beds of decomposed sandstone, which is itself at many places quite as coarse as the grit on which it rests. I got a fair collection of fossils from Fossil Point, and they bear a marked resemblance to those obtained last year from Little Omaha, but on Kawau a somewhat greater variety is to be found, only *Rhynchonella* does not appear to be so largely represented as on the mainland.

At Limestone Point the conglomerates and grits again come in, overlaid by marls which resemble those occurring at Little Omaha. As the gritty beds are followed round the point we find that they become very calcareous at places, and at Limestone Point they actually pass into a gritty flaggy limestone, which, with the exception of its impure character, is really very like the flaggy Whangarei limestone, and bears a yet closer resemblance to those limestones at the Waipu Cove and round the rocks at Bream Tail.

Along the beach between Momona and the copper mine conglomerates or pebble-beds again occur, resting unconformably on the slates, and these in their higher beds become calcareous, passing into a sort of impure limestone, above which marls similar in character to those which occur at Little Omaha are seen; but here they pass up into most characteristic Waitemata beds, with traces of plants and thin streaks of coal as at Mahurangi. At this point there is no sign of the concretionary sandstones coming in which occupy so considerable an area on the mainland. The dip of these beds where I took it was east, at an angle of 7°, but it is only a small patch lying as a syncline upon the slates.

On the N.E. side of the island the beds correspond exactly in character with those at Mahurangi; they consist of alternating beds of marl and sandstone similar to those last described, and with thin streaks of coal associated with them, and beds of the concretionary sandstone overlie them. The dip of the beds is about E.N.E. or seaward, and they are traversed by a fault which strikes N.W. and S.E., the same run which the slates, dykes, and reefs generally take.

Dr. Hector mentions, in his report on Kawau (Geological Reports, 1868–69, p. 48), that "the tops of some of the sandstone hills on the N.E. coast of the island are covered with a thin stratum of tufaceous sandy clay containing iron bands, a remnant of the layers of trachytic tufa that were dispersed over the bottom of the Tertiary sea during the eruption of the trachytic rocks, such as those which form Manaia, at Whangarei Heads."

I did not myself observe these trachytic tufas, but since they are there a further proof exists of the intermediate position which I have assigned to the Waitemata and Mahurangi beds between the trachydolerite breccias of the Manukau Heads on the one hand and the Whangarei or Mount Brown limestone on the other.

District between Auckland and Mercer, including Report on Mr. Hunt's Boring Operations.

I was instructed to continue the survey of the country from Auckland south to Mercer, and the accompanying map gives the result of my work. The formations represented in this map are as follow:—

1. Basaltic rocks.
2. Plastic clays and sands.
3. Waitemata marls and sandstones.
4. Papakura limestone.
5. Coal measures.
6. Slates.

The slates form the basement rock of the district, stretching from the edge of the Maungatawhiri Flat to Maraetai, on the shores of the Waitemata Harbour; and resting unconformably upon these come the coal measures in which seams of coal have been worked at Drury.

It was especially in connection with the coal-seams in this locality that I was instructed to examine the country, as the Hon. Mr. Chamberlin had again requested the Director of the Geological Survey to report on the district.

In 1878 Dr. Hector wrote to Mr. Chamberlin, in reply to his inquiries on the subject, as follows:—

"As you are aware, the workings have been abandoned for many years, and, the drive having fallen in, no exact observation could be made without going to considerable expense.

"The coal occurs in a 6-foot seam, but when formerly worked was divided into three portions by shale bands. This is, however, in all probability only a local character, as in other parts of the district the coal-seams are uniform in quality throughout the whole thickness.

"The measures were formerly worked on the face of a range of hills, and dip under the flat country lying between the hills and the Drury Railway-station.

"Borings made in this flat in 1860 reached the basalt that covers the coal at a depth of 69 feet. The thickness of the basalt is, as far as I can judge, less than 80 feet, so that the coal might be expected at less than 30 fathoms from the surface, but the depth would, of course, vary with the position of the shaft.

"The coal was of good quality for a brown coal, and quite equal to that at present worked in the Waikato at a much greater distance from the market. Its composition was—

"Carbon	42·0
Gaseous	35·0
Water	14·0
Ash	9·0
	100·0

"The workings were formerly abandoned at this place solely on account of the Maori war and the great cost of carriage. Both these difficulties are now removed, as the rails could be laid to the pit's mouth if the coal were worked in the flat, or right into the old workings if they are reopened."

As far as the prospects of coal being found on the flat are concerned, I can say nothing further than is contained in the above letter of Dr. Hector. As far as I have been able to judge, the coal measures at this particular point appear to keep a higher elevation than the flat, and at a short distance back into the hill dip N.E. at an angle of 15°, being exposed in several road-cuttings. This dip would certainly not carry the coal below the flat, and the only probability of it existing there seems to me to lie in the chance of a fault having thrown it down there. Whether this is the case or not is quite impossible to decide from surface indications, seeing that the whole of the flat land is composed of the "plastic clays and sands," beds of quite recent origin as compared with the coal measures. The case thus remains precisely where it was before, and until Mr. Chamberlin or some other enterprising speculator sees fit to put a borehole down on the flat the question of the occurrence of coal there is likely to be an open one.

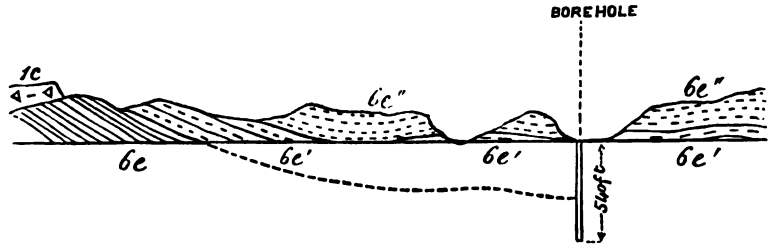
I have shown as nearly as I was able the boundary of the coal measures exposed at the surface, and there would appear to be a sufficient area to pay for reopening the old mine under such easy conditions as now exist.

With reference to Mr. Hunt's borehole at Mercer, you will remember that in my report on this district of February 1st, 1877, I stated that the evidence to hand led me to believe that the coal, which is worked at the Miranda, Taupiri, and Kupakupa, and has also been found at various other points skirting the slate ranges, and cropping out in the Whangaroa River, which falls into the Raglan Harbour, would underlie the whole of the Waikato basin. I then stated, "Of course the only way in which this matter can be set at rest is by boring; and a borehole put down either at Mercer or Churchill would settle the question, either for or against, and at a comparatively small cost. I am of opinion that Churchill would be the best place for boring."

The reason that I selected Churchill as the most suitable place for a borehole was that at this point the Leda marls, which overlie the coal directly at the Bridgewater Mine, occur on the surface, are lying moderately flat, and occupy what is approximately the centre of the basin.

Mr. Hunt's borehole at Mercer should, however, settle the difficulty equally well, but would represent a considerable amount more work in all probability, and the only reason that this point has been chosen by Mr. Hunt is that he is now boring on his own property, and is several miles nearer Auckland than he would otherwise have been.

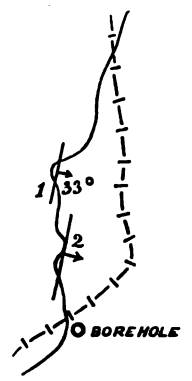
I gave a section of the beds near Mercer with that report, which I reproduce here :—



Section between Pokeno and Mercer. 1*c*. Basaltic tufas and ironsand. 6*e*. Leda marls. 6*e'*. Light-blue marls (Mercer). 6*e''*. Brown sands (Mercer).

This section I have no occasion to modify in any way, but may append the subjoined plan, which will show what has been done :—

The distance between the top of the Leda marls and the base of the Mercer sands, at which point the borehole was commenced (approximately), is, in the direction of the dip, rather more than one-eighth of a mile, as shown on the plan. The dip of the Leda marls is 33°, N. 30° E. magnetic, which would give a thickness to the blue marls of 359 feet, but the estimate can only be taken as an approximation. The bore-hole is now down 540 feet, the last 154 feet having been through hard and soft bands of sandstone and tough marly clay, so that it is probable that this distance at least has passed through the Leda marls and associated beds.



1. Marls (Leda marls), with *Pecten pleuronectes* in abundance. 2. Mercer sands, the intermediate space being occupied by light-blue marls and sandstone.

The following is a journal of the Mercer bore-hole :—

Ft.

15 .. Mercer sandstone. At 4 feet a small band of blue marl.
10 .. Blue marl.
2 .. Blue marl and impure fireclay?
3 .. Blue marl and fireclay?
26 .. Mercer sandstone as at surface.
17 .. Blue marl.
8 .. Dark fireclay?
34 .. Grey marl. Pebbles of mundic at 120 feet, and ironstone at 144 feet; thin vein of blue sand at 148 feet.
4 .. Grey sandstone.
1 .. Almost black fireclay.
15 .. Grey sandstone.
9 .. Light-grey clay.

Ft.	
130 ..	Grey sandstone. At 195 feet, fossil microscopical shells; at 218 feet, mundic and ironstone pebbles; at 235 feet, mundic; at 250 feet, black rock, thin vein; at 260 feet to 268 feet, mundic and ironstone, not waterworn.
10 ..	Hard freestone.
20 ..	Hard freestone bands 2 feet thick, with alternate bands of soft sand 6 inches to 9 inches thick.
46 ..	Soft sandstone rock.
1 ..	Fireclay.
10 ..	Hard freestone bands 2 feet thick, with bands of clay about 6 inches thick.
10 ..	Soft sandstone rock.
15 ..	Hard freestone bands 1½ feet, with soft clay bands about 1 foot thick.
154 ..	Alternate hard and soft bands of sandstone and tough marly clay.
540	

It is only right here to call attention to the fact that in 1876 I regarded these Mercer sands and marls as the upper member of the Leda marls, in contradistinction to Captain Hutton, who had placed them at Pliocene.

The result of my last year's work showed that the Waitemata beds, as developed around Auckland and further north, are undoubtedly of less age than the Cape Rodney beds, so that, if the Mercer beds are considered to be the equivalent of these, an unconformity must exist between them and the true Leda marls, and Captain Hutton would then be correct as to the position which he assigned them, although their age would be greater than he allowed.

Whether these Mercer beds are the equivalents of the Waitemata series proper I have no means of judging, and can only state that no apparent unconformity exists between them and the Leda marls as developed in the Waikato. Be this as it may, however, the question of the extension of the coal is in no way altered, as the Leda marls do occur throughout the basin, and until these have been bored through, and rocks inferior to the coal found, it will by no means be proved that a large coal area does not exist in the Waikato basin. It is unnecessary for me to devote any space to the description of the beds met with here, as they have been described frequently in other reports, and the map will explain itself.

THAMES AND COROMANDEL DISTRICTS.

My special object in examining these districts was to trace the relations between the coal series, auriferous greenstone trachyte, and the Tertiary trachyte series of Beeson's Island. I, however,

also visited several of the mines both at the Thames and Coromandel, and shall submit the results of my examinations.

At the Thames the relations between the two trachytic series are not quite so clear as at Coromandel, and again at Ohinemuri, but, all things taken together, I do not think there can be any doubt that the trachyte breccias, &c., are unconformably younger than the auriferous greenstone trachytes which occur throughout the district. The breccias are, moreover, younger than the coal series at Cabbage Bay resting upon them, but whether conformably or otherwise could not be determined here. Our knowledge of these breccia beds, however, in other localities, I think warrants me in stating that they are unconformably younger than the coals.

While I was at the Thames I first of all visited the Golden Crown and Tookey's old claim, which is now being opened up again by a new company. In the Golden Crown they have two reefs, which, I understand, meet in the Caledonian. The strike of these is about N.E. and S.W., with an underlie to the westward; and No. 2, which is the lower one, is now being opened up with, at one place, a slide 2 feet or 3 feet thick of a dark-grey mullocky clay, all of which is put through the stampers and returns a fair yield.

Between these two reefs the country is one mass of stringers which run from one to the other, and it was in a small leader of this sort, called the Specimen Leader, that the richest gold in the Caledonian Claim came. Some rich country has been found in the Golden Crown, both in these leaders and also in the reefs. The rock in this mine is a pyritous tufaceous sandstone, which is at times very hard; it is however more or less decomposed, I think, although some parts of it have to be blasted. It is traversed at places by what are known to miners as "soapy backs," which are very dangerous in the working, the rock being liable to peel off in large blocks when least expected.

At Tookey's old claim the workings are at present in small leaders, running parallel to the main reef, and very little work has been done there by the new company as yet. They have, however, got a little gold in some of the leaders. The rock is of the same character as in the Golden Crown.

The Moanataiari Mine, which is very well worked, taps more country than any other in the district. I find in this mine that the strike of the reef is about N.E. to S.W., with the underlie to the westward, and that to the east a big slide, sometimes as much as 30 feet through, traverses the country from north to south, with a westerly underlie. Above this slide, or to the seaward side of it, the country, although frequently hard, is yet traversed by a number of joints which render the ground easy shooting; but after passing through the slide it becomes far more solid and compact, and Mr. Comer, the manager, informs me that in this hard ground no payable gold has yet been found in the reefs. The strike of the reefs, which average N.E., would cause them to intersect this

slide at an acute angle, and hard bands of rock, locally termed dykes, also traverse the country parallel to the reefs. It is generally between these so-called dykes that the richest gold has been obtained, and the feeders of quartz dropping into the reefs also appear to enrich them.

The compressed-air rock-drill is working in this mine with remarkably good results, and I understand that with it they can drive 36 feet in a week through hard ground.

In the Caledonian Mine there is not a great deal now to be seen, as all the old workings are filled in. The reefs however appear to strike from N. to N. 60° E., and, from what Mr. James, the manager, informs me, three of these at least run together. This ground is all to the seaward side of the Moanataiari big slide, which, by the way I should have mentioned, splits in the Moanataiari, one part lying very flat and frequently carrying some very rich gold near it, and the other going down steeper and cutting off the gold almost entirely to the eastward of it. This slide is again seen in the Golden Calf, where it has lately been struck; but does not show in the Caledonian, unless it be found at much lower levels than have yet been reached. It appears to me that at present very little more than specimen-hunting is being done, and that it would be advisable to sink deeper and cut the reefs at their junction with this slide at lower levels, since no doubt gold occurs at much greater depths on the western side of this slide, while on the eastern side it has not as yet been found in payable quantities until passing for a considerable distance to the eastward.

At the Little Agnes, up Tararu Creek, galena and zinc-blende with a little copper pyrites has been found, and the mine is now held by Captain Thomas. The reef is from 3 feet to 17 feet wide, and has been worked for gold, some very good stone being obtained. The rock is a tufaceous breccia, and the lode is striking N.E. to S.W., and dipping eastward at very high angles, indeed standing nearly vertical.

Up Tararu Creek a considerable variety of rock is seen, and several hard bands of rock, locally known as dykes, occur, of which I have brought specimens; but the whole country is one which I am unable to take in at a glance, and would require very careful work before any opinion could be formed concerning the distribution of the gold. I find myself far less able to form any opinion on the subject than the more intelligent of the managers, as it is quite impossible to carry the system of reefs and cross-slides in one's head without an intimate acquaintance with the country.

The lode at Captain Thomas's mine is not well exposed at present, as he has only just taken the place over, and is opening out old drives. Some of the ore appears good of its kind, but it is composed of too many different minerals to be of a great deal of value, unless gold or silver were found to be present in payable

quantities. Messrs. Johnson and Matthey's assay of this stone showed the presence of 1·15 oz. gold and 15·15 oz. silver per ton, and it is worthy of note that some of the gold sold from this mine had a value of only 16s. an ounce, so that free silver must necessarily exist.

The Alburnia and North Devon Mines are situated to the eastward of the Moanataiari slide, but at some distance away from it, and they have been yielding some very rich stone: at the North Devon I saw some of the richest gold that I have seen on the field.

I understand that in the old Piako Mine, which fell in some time ago, gold was got to a depth of over 500 feet below sea-level; and the Queen of Beauty is now sinking to tap the same ground.

After visiting the Thames, I rode over to Ohinemuri, which, at the time of my visit, appeared to be all but deserted. At Mackaytown, where the first of the rush occurred, the place appears to be quite abandoned—no one working there at all, so far as I could see.

Between Mackaytown and Owharoa the road goes over some hills which I consider belong to the tufaceous beds of Tertiary age, and which are frequently breccias. As we descend the other side of the hill, however, a somewhat interesting section is seen, exposing black marls at places interstratified with tufaceous beds, and at others included as large blocks in decomposed tufaceous rocks. The black marls yield no sign of fossils, as far as I could make out, but they decompose to a light-brown marly clay, which occupies a good bit of country here. At Owharoa, the Radical is the only mine at present working, and the gold is being got out of thin leaders traversing a sort of decomposed trachyte-looking rock. The strike of these reefs is the same as the prevailing strike at the Thames, namely, N.E. and S.W., and some very good gold is got here in patches, but the place appears to be almost abandoned now.

Between here and Waitekauri nothing of interest is to be seen, beyond what is described by Dr. Hector (Geological Reports, 1870–71, p. 100); but at Waitekauri a large reef, 25 feet wide, which at the date of Dr. Hector's visit had not been discovered, only leaders being then known, has since been found and worked, and is now abandoned by the original company. It is said to contain a few pennyweights of gold throughout the stone, but not sufficient to pay for crushing, and only the richer parts of the reef have been worked. This really means that it was worked as long as moderately rich quartz was to be got out easily, and then abandoned. It is at present worked to a small extent by tributers, but what is being done is of but little value in proving the reef.

Coming back to Paeroa we took the track which had been specially made to the Waitekauri Diggings, and, as the low country

is reached, most unmistakable instances of the Tertiary trachyte breccias lying unconformably upon the auriferous diabasic series are seen.

At Coromandel, a somewhat greater variety of rocks occurs, the basement rocks of the series consisting of slates, which in many cases resemble in character those of the Te Anau series, but, so far as I have seen, do not appear to be interstratified with breccias, as they are farther south. These slates occur in the Tiki, forming what is there known as the Golden Belt. A battery has been erected on these slates just below a waterfall, and a tramway and fluming brought in, a good deal of gold, I am informed, having been obtained in patches from this locality from time to time. At present this locality is entirely deserted, and I can only quote what I was told by miners concerning the former workings.

After ascending the hill over the Golden Belt, and passing to the westward, decomposed tufaceous rocks come in, and in these numerous short tunnels have been entered, but, as they do not appear to have been carried far, I do not imagine any very good results have been attained. This belt of tufaceous rocks probably extends to the Tokatea, and the same series extends to the Union Beach and Kapanga Claims. The run of the auriferous country from the Union Beach to the Tokatea appears to be north and south, and the strike of the main reef, which is a very large one, is also north and south to north-east, with an underlie to the westward. Parallel to this, and in the direction of Kennedy Bay, a felsite dyke occurs, which also strikes north and south, but underlies to the east. The belt is very thick, very hard, and contains a large quantity of lime as calcite, and is also itself impregnated with lime. It is between these two, the reef and the dyke, that the greater quantity of the auriferous stone has been found, as small leaders which drop into the main reef.

The main reef occurs in what the miners call a sandstone country, but which is really a decomposed volcanic rock; it has never as yet proved to be remunerative, but is reported to carry a few pennyweights of gold per ton. In this district, as at the Thames, it is in the more decomposed rocks that the payable gold appears to occur, and the only reason which suggests itself to me for this is that decomposition in rocks is very often due to the presence of iron pyrites, which is liable to change, and Mr. Skey has shown that decomposing pyrites has the power of precipitating gold from solution. Under these circumstances, what would produce one of the phenomena would also produce the other. Whether this would be borne out by a careful examination of the country I cannot say, but I think a careful study of the whole district would be of the greatest value, and the managers would one and all supply all the information in their power.

Round the flanks of these slates and older volcanic rocks the Tertiary breccias of Beeson's Island flank, resting quite uncon-

formably upon them, and indiscriminately upon each. They exactly correspond in character with the breccia beds of the Manukau Heads, being composed of a coarse volcanic agglomerate traversed by at least one dyke on Beeson's Island, a dolerite dyke also occurring close to the Union Beach Claim, and probably running through these beds.

In the direction of Cabbage Bay these breccias rest on the coal formation, which in turn rests unconformably upon the slates.

A seam of coal 5 feet in thickness has been discovered on the face of the hill which falls to Cabbage Bay. It is dipping into the hill at an angle of 30° E., the strike thus being about north and south. Numerous small drives, &c., have been made round the spur, with the view of following the coal, but these have not been successful after passing a short distance away from the original outcrop. I am of opinion that these explorations have been carried on too high up, as the dip and angle of the hill would carry the coal-seam a good deal lower than they have been looking for it. Round the spur and up the creek a drive has been put in for about 30 feet, but here it is only just above the slates, and is therefore too low to strike the coal. On the opposite side of this creek there is a well-marked deposit of the coal measures resting on the slates and lying very flat, but the coal has not yet been found in them; there is little doubt, however, that by a careful examination of the beds of some of these creeks, which are simply mountain torrents, and which expose every foot of the strata, the seam may be found.

The present outcrop, however, is situated too far from the water to render the property of any great value, since not less than four miles of tramway would be necessary to bring it to seaboard.

The coal, moreover, is very impure, containing an exceptionally high amount of ash; the following being an approximate analysis:—

Fixed carbon	59·02
Hydrocarbon	2·69
Water	2·31
Ash	35·98
	100·00

Evaporative power, 7·67 lb.

I have not attempted to trace the extent of this deposit, as my instructions did not include this work, but I should imagine that it covered a considerable area: this, however, can only be proved by careful work, and in so rough a country would involve some time.

DISTRICT BETWEEN THE AORERE AND TAKAKA VALLEYS, COLLINGWOOD.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT-GEOLOGIST.

11th March, 1881.

I HAVE the honor to inform you that, in accordance with your instructions of the 9th December, 1880, I have proceeded with a geological survey in the Collingwood District, with a view of connecting with previous work at the head of the Takaka and Karamea Rivers.

The district which I have examined is chiefly the mountainous country between the Aorere and Takaka Rivers from which the Anatoki, Slate, Rocky, and Snows Rivers take their rise; also that part of the ranges nearer the coast-line from which the Parapara, Purumahoe, Waingaromumu, &c., are fed. I also examined the Quartz Ranges, and parts of the Lower Aorere, as well as the western side of the Takaka Valley, in order to determine boundaries in some cases and in others to make collections.

NARRATIVE.

I left Nelson for Collingwood on the 29th December, 1880, arriving there on the 30th. On the 31st I rode up to Salisbury's Creek to see the locality at which certain fossils had been discovered, and on the 30th January visited the Perseverance Mine. On the 4th, 5th, and 6th, I was engaged about the hills at the mouth of the Parapara River and Onakaka Creek, and on the 9th I left for the Slate River, arriving at the Castles that night. On the 8th I moved on to the upper crossing of Rocky River, where I camped, and from that date until the 14th I was engaged on the mountains in the interior of the district from which the Anatoki, Slate River, Boulder, Rocky, and Snows Rivers take their rise.

On the 15th, 16th, and 17th we moved camp to the Quartz Ranges, and from that date to the 22nd I was engaged on the examination of the Quartz Ranges to Salisbury's Creek and making collections at the latter place.

On Monday, the 24th January, I went up the Puruwhakaho Creek, and arrived at the Waingaromumu Diggings on the 26th, between which place the Anatoki Diggings and Rangiacata Head I was engaged until the 1st February. On the 2nd February I rode up to Bates's, on the Waitui, and from there examined the country towards Salisbury's open; and returning I paid some little attention to the crystalline and Cretaceo-Tertiary limestones around Mr. Sparrow's. I returned to Collingwood on the 8th, and from then until the 12th I had my time fully occupied examining the Perseverance, Richmond Hill, and Red Hill Mines, leaving for Nelson again on the 13th February.

Report.

The results of my explorations are to class the rocks found in the district under the following heads :—

1. *Recent.*—Alluvial deposits, including the younger auriferous washes of the various creeks.
2. *Pliocene.*—Old river terraces represented by the older Parapara wash, the quartz-wash of the Quartz Ranges and Golden Gully, and the river terraces overlying the marls on the sea-coast, also the Waingaromumu Diggings.
3. *Cretaceo-Tertiary.*—Calcareous series, from the limestone downwards.
4. *Upper Devonian.*—(*a.*) Te Anau series of slates, sandstones, and breccias.
   (*b.*) Schistose rocks, representing metamorphosed areas of (*a*).
5. *Lower Silurian* (?).—Crystalline limestone, bituminous and hornblendic schists, with pyritous veins and heavy deposits of ironstone at Parapara.
7. *Granites and gneissose rocks of the district.*

Granites and Gneissose Rocks of the District.

The granites occupy but a small surface-area in the district under immediate consideration, but still would appear to have played an important part in the geological features throughout. They occur as a boss at the Waingaromumu Diggings, extending from there, as shown on the accompanying plan, in the direction of Onahau. They vary a good deal in their degrees of coarseness at this part of the field, sometimes being largely porphyritic and at others quite fine-grained. They are, moreover, traversed at places by veins of a micaceous nature, which resemble the Richmond Hill lode stuff, and one of these yields 2 oz. of silver per ton to assay, so that possibly another instance of the tetrahedrite may be found here, more especially as a small amount of copper pyrites occurs, associated with the rock. The granite throughout this area also appears to be more or less decomposed, as the hills are all covered with a deposit of quartz-grit, and I think it is not improbable that the swampy flats which occur in the gullies contain deposits of kaolin clay from the decomposition of the felspathic constituents of the rock.

The granite is not met with again until Lead Hill, which bears W.S.W. from here, is reached. Here a large boss of granite occurs, forming Lead Hill and Mount Olympus, and rising to an altitude of about 5,000 feet. Lead Hill itself is an imposing-looking mountain, even from the lake at the head of the Boulder River, which is itself 2,850 feet above the level of the sea. It rises from the very edge of the lake, which, by the way, is one of the best

instances of a true rock-bound lake-basin that I have seen, and is entirely devoid of vegetation to the summit, with the exception of a few dwarfed subalpine plants and snow-grass in the hollows. At a very considerable elevation, I should say about 4,000 feet, a small lake occurs in a depression on the side of the hill, and this is drained by a waterfall which delivers itself into the Boulder River, and I am informed that another small lake occurs nearly at the summit. I did not ascend this hill, as I had no special object in doing so, seeing that it is entirely composed of granite. Near the base of the hill, on the lake side, there are at times masses, several chains in length, of hornblendic and mica schists, which give one the impression that the whole mass is stratified where they are seen; they are, however, more probably due to the complete metamorphism of certain included masses of rock when the eruption occurred. A very fine glacier valley drains into the lake, and the lateral moraine has caused the formation of another small lake, at an elevation rather greater than the main one.

Gneissose rocks occur in the vicinity of Richmond Hill, on the Parapara River, but they appear to be interstratified with the lower beds of the Lower Silurian rocks next to be mentioned. It is, however, interesting to note that the Richmond Hill silver ore occurs in these beds, a similar rock, which also carries silver in small quantities, being found in the granites at Waingaromumu.

Lower Silurian (?).

These beds consist of crystalline limestone, bituminous and hornblende schists, with pyritous veins and heavy deposits of ironstone as at Parapara. Besides these, the gneissic rocks of the Parapara River just mentioned must be considered as belonging to this series, and also the steatites and talcose rocks, which occur as irregular masses in them, evidently due to special conditions under which their metamorphism was locally effected. This formation covers a considerable area in the district which I have examined. It stretches down the Parapara River from above McGregor's Creek and Golden Gully to its mouth, being on its western side overlaid unconformably by the schistose rocks in which the Perseverance and other mines have been excavated. It appears to rise the hills across Glengyle Creek, and probably the rocks around Appo's Flat and below Ross's mine at Red Hill belong to this formation; but here they consist of quartzites and a much-decomposed felspathic-looking rock in which quartz leaders are by no means rare. They extend through the coast range, which occupies the right-hand side of the Parapara near its source, and from a point a little to the north of the trigonometrical station recently erected at the head of the Puruwhakaho Creek their boundary may be approximately mapped by a line running from there to the lower slope of "Gentle Annie," the hill opposite Beardmore's, on the Waitui River, over which the

track to the Mount Arthur table-land goes. All the rocks lying to the eastward of this line belong to the Lower Silurian formation until they are overlaid by the Cretaceo-Tertiary limestones or the gravels of the plains, and they rise again on the opposite ranges, as shown. Generally speaking these rocks are very regular in strike and dip, the coastal range from the Parapara eastward consisting of a very sharp syncline, which runs out to the northward about the locality of the mouth of the Parapara, and spreads slightly to the southward, thus spreading the formations and allowing higher beds to come in. The limestone offers a striking illustration of this at the mouth of the Parapara River, one main outcrop following that river down its course, while another runs from its mouth in a south-east direction. As far as can be seen from the observations one is able to take in river-beds and the bush, the strike and dip of these beds are moderately constant, the strike seldom varying much from north and south, while the dip is to the east on the west side of the syncline, and to the west on the east side. That certain contortions do, however, occur in these beds, is, I think, made evident by the irregular exposure of some of their beds, and, as the limestone is the most marked, and, perhaps, the most readily recognized, I will instance this. The limestone occurs as a narrow belt from the mouth of the Parapara up to Richmond Hill, after passing which point it expands rapidly, running into the head of Golden Gully on one side, and Happy Valley, a branch of the Parapara, on the other, and in this locality is about as broad as it is long. This sudden expansion of a bed could hardly, I think, be brought about in any other way than by a contortion of highly-tilted strata, unless, indeed, they assumed a flatter dip at that point, which I can see no sign of their doing. A further proof that these contortions do occur is seen in One-Speck Gully, a creek which falls into the Anatoki near its mouth, where the strike of the rocks varies at places to east and west, while on the hills they are striking north and south. The sharp contortions at right angles to one another are thereby proved in the vicinity of the granites against which they have been crushed. These contortions, I conceive, explain the belts of limestone which occur in the Riwaka Range on the opposite side of the Takaka Valley, and the crush by which they were formed appears also to account for the partial metamorphism of the Te Anau series next to be described in this district. On the western side of the Takaka Valley these rocks occupy the comparatively low ranges which flank the main ones, and through which the Anatoki and Waingaro Rivers have cut. The limestones generally occur farthest out towards the valley, with, at places, as at Mr. Sparrow's, the younger Cretaceo-Tertiary fossiliferous limestone resting unconformably upon them, and as we reach the Waitui these younger fossiliferous beds completely cut out the older limestones on the western side of the valley. It is associated with these rocks that

the well-known Parapara hæmatite occurs, which, as pointed out by Mr. Binns (Geological Reports, 1878–79, p. 63), is found as immense boulders in the Onakaka Creek. I followed this creek up carefully as far as the waterfall, which is over limestone, without seeing any sign of the hæmatite *in sitû;* but there are, as Mr. Binns mentions, enormous boulders of many tons weight in the creek. Mr. Arthur Washbourn informs me that he has seen the ironstone above the waterfall, so I concluded that it was following the line of the limestone. It does not appear again in the Puruwhakaho Creek, being possibly represented there by pyritous veins, of which there are several; but further south again, on the summits of the spurs above Waingaromumu, I again traced it as boulders having a vesicular form and looking very much as if they had come from the back of a reef. I mentioned (Geological Reports, 1874–76, p. 60) the occurrence of a solid pyritous lode in the Parapara, above McGregor's Creek, where it crops out in the limestone, and I have very little doubt that the Parapara hæmatite is in reality the gossan of a large pyritous lode occurring under similar conditions. The great extent of the ironstone deposit at Parapara is not, I apprehend, due to the existence of such a very large reef as might be supposed; as, if a reef of only moderate size, and decomposed to the state in which the Parapara ore occurs, were exposed at the surface it would soon, by its waste, cover the three sides of the spur on which it was found. It is, moreover, apparent that in the greater part of the area over which this ore is found it is not *in sitû;* and the number of pyrites crystals and cores of pyrites which occur in many of the boulders show that this ore was originally a sulphide, and has only assumed its present form from oxidation at the surface.

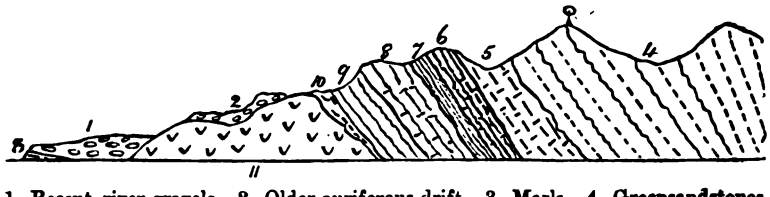
The following section illustrates the characters of the formations in this locality:—

Section from coast, through Parapara Hills. 1. Gravels. 2. Blue marls. 3. Quartzites. 4. Granular mica-schist. 5. Limestone. 6. Ironstone. 7. Quartzose micaceous schist. 8. Quartzite and quartz.

Bituminous schists have also been found associated with this formation elsewhere, and the beds give an equally good account of themselves in this locality. Pieces of graphite, generally of an impure character, may be picked up in most of the creeks which cut across the strike of these beds, but it was only in the ranges at the head of the Puruwhakaho that I observed them *in sitû.* At this point they occur overlying the limestones, and containing

specimens of a very fair class of plumbago. They, however, require special examination before it could be decided whether any well-defined veins of the pure mineral occur, and, even should they, the locality is not one which could be got at without some considerable expense. The strike of the rocks would carry these beds through to the Onakaka, above the waterfall; and I have no doubt that they could be traced for the whole distance should it be found desirable to do so.

The following is a typical section of these coast ranges, and is taken from the Takaka River through the Waingaromumu to the trig. station:—



1. Recent river-gravels. 2. Older auriferous drift. 3. Marls. 4. Greensandstones, &c. (*Te Anau*). 5. Schists (quartzose). 6. Blue limestone. 7. Carbon slates (graphite). 8. Crystalline limestone. 9. Grey schists and hornblende schist. 10. Talcose schists. 11. Granite.

The Waingaromumu springs deserve a special mention in connection with this formation, more especially as I am not aware that they have been previously described. These springs, which are intensely cold, are sufficient to afford a constant supply of water, all the year round, to a large river. They issue on a plain which is bounded on one side by the granite and on the other by a high terrace of river-gravels, and the flat itself consists of gravels. The main basin from which the spring issues appears to be of solid rock, but no specimens of this could be obtained on the surface. It is, however, about the position which the limestone would occupy on the surface, and round some of the smaller springs there are calcareous encrustations, so that it is probable these springs do issue through limestone. It is a well-known fact that during the summer months a portion of the Upper Takaka River is dry along its course, and there can be no doubt it follows a subterranean channel for that distance, and it is probably from this subterranean channel the Waingaromumu springs derive the bulk of their water.

Upper Devonian (Te Anau Series).

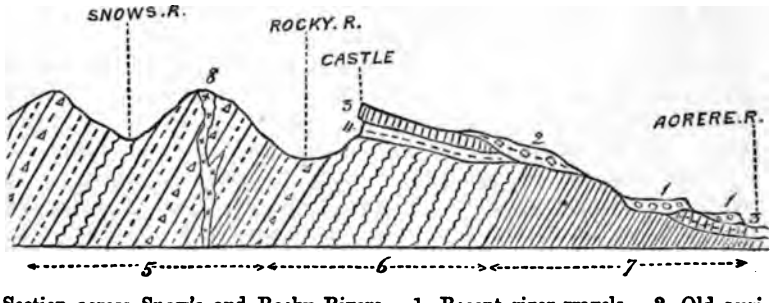
(a.) *Slates, sandstones, and breccias.*
(b.) *Schistose rocks, representing metamorphosed areas of* (a).

These rocks occupy by far the greater part of the country which I have been over, in one or other of the foregoing forms. The

characters of the unmetamorphosed rocks have been very well described by Mr. McKay in his report on the Baton River and Wangapeka districts (Geological Reports, 1878–79, p. 127). He says, "The rocks are porphyries, amygdaloidal tufas, &c., interstratified with beds of greensandstone and fine-grained green breccias, followed by an occasional band of dark-coloured slate, most of which rocks are dipping west. Westward of this in the main range the beds consist of breccia conglomerate, containing a great quantity of quartz but no porphyritic rocks: these stand nearly vertical, or dip at high angles to the east."

It is in these rocks that all the main rivers of the district take their rise; Snow's, Rocky, Slate, and Parapara Rivers rising on the north-western side of the watershed, while the Anatoki, Waingaro, and Takaka fall to the eastward, draining the whole of the country from Mount Peel and Mount Snowdon to the trig. station at the head of the Puruwhakaho Creek. The Boulder River, which also rises on the western side of the watershed, has its source at the junction of the granites at Lead Hill with the metamorphic equivalents of these rocks.

The metamorphosed rocks generally occupy the comparatively low grounds stretching from the Quartz Ranges through the Slate River, near its mouth, to Bedstead Gully and Cole's Gully, shortly after which they are covered up and obscured by more recent deposits. They are, generally speaking, the lowest rocks of the series, but in Snow's River schistose rocks occur interstratified with the sandstones and slates which form the ranges on each side, as shown in the following section:—

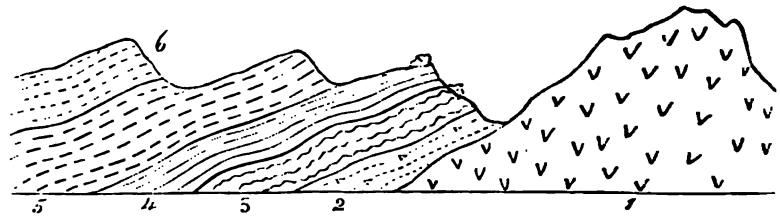


Section across Snow's and Rocky Rivers. 1. Recent river-gravels. 2. Old auriferous wash of Quartz Ranges. 3. Limestone. 4. Calcareous sandstone (fossils). 5. Te Anau series (unaltered). 6. Foliated schists (felspathic). 7. Blue and black slates. 8. Dyke.

Captain Hutton has described these lower beds (Geological Reports, 1870–71, p. 152) in his description of the Perseverance Mine. He says, "The oldest rock found in this district is a dark-blue laminated clay-slate, fissile in its upper portions, but

becoming more solid below. It is slightly cleaved and slightly contorted, and weathers into a dark-coloured, almost black, clay. Resting conformably upon this clay-slate is a finely-laminated felspathic slate, usually of a grey or greenish-grey colour, often in the lower portions with imperfect crystals of hornblende developed in the planes of the bedding. Occasionally it passes, especially in its upper portions, into a hard quartz schist, which is generally traversed by thin veins of white amorphous quartz." These slates are again seen as we approach Slate River, where they are fine-grained silky fissile slates, and at the crossing are dipping E.S.E. at an angle of 45°. After crossing the Slate River, and commencing to ascend the spur on the south side of it, another outcrop of slate is passed dipping south at an angle of 45°, but it is probable that this is only a local disturbance, seeing that at a short distance further on the old dip occurs again. After passing this no outcrops are seen, the slates being covered with gravels until the bush track is reached, where the calcareous sandstones and limestones which have yet to be described come in. Beyond these limestones, which occupy a plateau country, fine-grained silky mica-schists occur, much resembling those seen at the Paringa Lake; they strike E. 10° N., and dip east at an angle of 45°, and rise to form sharp spurs and ridges behind the flat plateau limestone country. A band of quartzsite occurs interstratified with these rocks, but could not be traced for any distance owing to the nature of the country. After rising out of the bush—I am describing the country along the track from Slate River to the Boulder Lake—the grey felspathic schists occur, dipping S. 60° E. at an angle of 50°, and these continue with no marked change in their characters until reaching the before-mentioned lake, where the granites come in forming the whole of Lead Hill, and have altered these rocks to a certain extent near their line of junction. Immediately below the grey felspathic schists, black carbonaceous slates make their appearance, also dipping S. 60° E. at an angle of 45°, and these carbonaceous slates have small segregations of quartz interstratified with them in the same manner in which the auriferous quartz occurs at the Perseverance Mine; and all these schistose beds have a wavy structure on a large scale, causing the angle of dip to change frequently. The strike of the rocks on the borders of the lake is about N.N.W., and the dip north-easterly, the black carbonaceous slates passing down into fine silky slates or schists very similar to those which occur at Reefton, and these again pass down into schistose rocks which more nearly resemble the Riwaka schists with garnets than anything else; they do not, however, contain garnets as plentifully as at the above locality, and the marbles appear to be entirely absent at this point, from which it may reasonably be argued that these rocks have only assumed this character from the close proximity of the granite, and are not in any way associated with the Lower Silurian rocks last described;

and my work generally has borne out this conclusion. The following section will illustrate the relations of these beds :—



Section across Lead Hill and Boulder River. 1. Granite. 2. Schists with garnets. 3. Fine-grained silky schists. 4. Carbon-schists. 5. Felspathic schists. 6. Greensandstones (Te Anau).

These schistose rocks flank the granite again at the head of the valley which drains into the lake, and form the greater part of the saddle, rising into serrated peaks, and striking N.N.W. to N.W. with an easterly dip, thus passing below the unaltered Te Anau rocks. The felspathic schists again form the bed of Rocky River where the workings are, and are seen as a tongue in the bed of Snow's River; but these I shall mention again further on. The black slates which occur at the mouth of the Slate River strike through to Bain's, on the Aorere, where they are again cropping out, being overlaid unconformably by the limestone, &c., and they may be seen in all the small creeks along the way. At Salisbury Creek, on the Aorere, the schists again occur, while the limestones are close to them, resting unconformably on their upturned edges.

In the Quartz Ranges the schists form the main bottom for the gold workings, and in this locality they are principally black, strike about N. 85° E., and dip northerly, thus turning against the granite in the same way that the Lower Silurian rocks do over at One-Speck Gully (see *ante*, p. 45). They are very finely laminated, and exhibit a tendency to split readily into slabs, but not of sufficient regularity to be of any value; they also contain some veins of quartz, but these have not yet been shown to contain any gold.

Resting upon these schistose rocks come the unaltered beds of the Te Anau series, which have been previously described. They are seen on the eastern side of Rocky River at the upper crossing to Snow's, and form the hill between these two rivers, occurring in the Brown Cow and Captain Cook's Nose, and stretching along the ridge which leads to the eastern side of the lake. The strike of the rocks is north and south, and the dip easterly, at an average angle of 45°. They vary from a dark-green coarse sandstone to a fine-grained bedded slate, and in the ridge at the head of Snow's and Rocky a hornblende syenite crops out, Mount Snowdon bearing 175°, and Mount Goutland 215°. The strike of these rocks

would carry them through to the country around Mount Peel, where Mr. McKay has shown that they occur, and from the character of the country there is no doubt that they are continuous for that distance; the altitude of the saddle is 4,400 feet, and Mount Peel bears 165°. On descending the hill into Snow's River these rocks are seen to occur, with veins of hornblende porphyry, until nearly reaching the bed of the river, where schists are again met with, striking N.W., and dipping N.E. at an angle of 45°. These schists do not appear to extend up Snow's much higher than John Young's old camp, where they pass into the Te Anau series proper; and on rising the hill on the opposite side, between Snow's and Slate Rivers, known as "Kill-me-Dead," the schists are soon lost, and the unaltered rocks come in again, and on the summit they are striking north and south, and can be seen running through the Anatoki towards the head of the Takaka River and Salisbury's open. They are bounded to the north and east by the Lower Silurian rocks, as already described, and come down very nearly to the edge of the Waitui River opposite Beardmore's, where they are overlaid by the Cretaceo-Tertiary limestones next to be described. It is from these rocks that the greater amount of the alluvial gold found in the rivers has been derived, and, although up to the present time no reefs of importance have been discovered, I have every hope that rich ones may yet be found. As pointed out last year, it is in these rocks that the auriferous reef has been discovered on Mount Arthur, and the main of the evidence throughout the colony now appears to point to this Te Anau series being the true gold-bearing formation of New Zealand. It is also in the lower and metamorphosed rocks of this series that the Perseverance reef occurs, which, as pointed out by Captain Hutton, conforms to the bedding of the strata, and always occurs at the junction of the black slates and overlying felspathic schists (Geological Reports, 1870–71), bunches of galena and zinc-blende occurring as disconnected patches above the reef and in the grey felspathic schists. Some attention has recently been again devoted to this mine by a party of Nelson speculators, and a drive has been opened out from Kelly's Creek to intersect the No. 3 level, where a deposit of galena and zinc-blende was previously known to exist. This drive, after following a somewhat sinuous course, has succeeded in striking the old stopes, and the galena and blende are there, sure enough, but when I visited the mine were very much intermingled. They were moreover occurring at the junction of the two rocks, and not in the upper one as previously reported, and were associated with white quartz, in which crystals of leucopyrite were of frequent occurrence, and some parts of the reef were composed of an intimate mixture of this leucopyrite, blackjack, and galena. At other parts of the reef the blende was of a honey-yellow colour, and, while occurring in a distinct form from the galena, was yet much mixed up with it. A small belt of rotten-

looking quartz also occurred, which, I understand, has been found to contain a little gold.

The reef was about 4 feet thick where I saw it, and the men were then driving to the dip, as their drive had brought them to the bottom of the stope from No. 3 level. Assays of various specimens from this reef show that the fine-grained galena carries 9 oz. 0 dwt. 23 gr. of silver per ton; the mixed ore above mentioned with leucopyrite gave 7 oz. 0 dwt. 18 gr., which was mainly silver, but contained traces of gold; and the white quartz with leucopyrite gave, on roasting and amalgamating, distinct traces of gold, but too small to weigh. As regards working, the mine is now in but little better position than it was before the drive was put in, as all or nearly all the stone has been stoped out to the rise, and the workings are now being carried on to the dip, which is all very well as long as no water is met with; but seeing that pumps were used in the inclined shaft when the mine was formerly worked, this state of things cannot be expected to last for long, and it will be necessary either to sink and pump, or else put in an adit from a lower level. I have not paid sufficient attention to this locality to point out where a drive of this sort could be entered to advantage, and indeed it could only be settled by careful survey, and a study of the old workings.* The ore is also of so mixed a character as to render its separation into a marketable form a matter of some difficulty, and it is questionable whether it would pay to work the mine for any one of the minerals found, unless gold should be shown to occur, when it would doubtless be worth while saving the other minerals met with.

The Perseverance Mine has yielded a large quantity of gold, and there is no reason to believe that it has been worked out; besides, as the present party hold a lease over the old Decimal ground as well as the Perseverance, and this company worked their mine as long as they were allowed to use the inclined shaft of the Perseverance, there can be no doubt that gold yet remains in the mine, which could be got out by an energetic company.

Mr. Ross, who, I understand, has a grant from Government for prospecting Red Hill, has carried on a large amount of work in the way of drives, and has succeeded in cutting an east-and-west reef which runs irregularly through the decomposed felspathic rock of which Red Hill is composed. This reef varies a great deal in thickness, from 10 feet downwards, at places running out to a mere line, the two walls having come together. It is, moreover, not a true quartz-reef throughout its course; but at times the fissure is filled with quartz, at others with mullock. A large number of north-and-south leaders feed this reef, and at places Mr. Ross has spent a good deal of time in following these. He informs me that gold can be got throughout this country, and that nearly all the

* The Decimal long drive was intended to do this.—J.H.

stone shows a prospect when crushed and washed. I can only say that, as far as I saw, very little gold was visible in the stone—indeed, I only saw two doubtful specks—but that in two samples, which Mr. Ross crushed and washed while I was there, there were certainly a few colours.

Cretaceo-Tertiary Series.

These rocks are represented in the district by limestones and calcareous sandstones passing downwards in places to marls, and at others resting unconformably upon the slates and schists, an unconformity probably existing between the calcareous sandstones and the marls.

The marls may be briefly dismissed with the mention that they occur along the coast-line from Collingwood towards Takaka, where they stretch back to the older rocks of the ranges, lapping well up on to them. They are not very fossiliferous, with the exception of very minute forms, such as nummulites, *Cristellaria haasti*, with *Saxicava*, &c.

Resting on these at Rangiaeata Head come the calcareous sandstones, &c.; and these beds, sometimes passing down into true limestone, may be traced in patches as far up the Takaka River as I went—viz., to Beardmore's, on the Waitui, two miles above the track which crosses the Riwaka from Nelson. They are resting sometimes on marl; at other times they are found reposing unconformably on the old crystalline limestone, and yet higher up the valley they lie at high angles (30°) against the Te Anau rocks, which nearly reach the plains in Gentle Annie. They doubtless extend up the Waitui to where they are shown by Mr. McKay in his map of the Mount Arthur District (Geological Reports, 1878-79, p. 122).

On the Aorere side of the range they are met with at the Devil's Boots (Rockville), and extend back to the caves above Bedstead Gully, at which place they are resting upon the black slates, the caves being frequently cut as much in the slates themselves as in the limestone. They again occur on the opposite side of the Slate River at the Castles, appearing at the surface along a plateau country at an elevation of about 1,800 feet, extending nearly to the scar f the Boulder River, but occupying no great width on the surface, being overlaid by gravels. Here the limestones pass down into calcareous sandstones, which yield *Lucina, Lima, Panopæa, Bryozoa, Waldheimia*, &c.; but the collection from this point was not a very perfect one. At the base of these sandstones is a thin bed of gravel, which I was informed carried a little gold at places. After reaching the low grounds around the Aorere at Mr. Bain's the limestones are again met with, forming the bed of the river, and they extend as far as Salisbury's Creek, being at times however covered by river-gravels in the terraces. They are cut by the Silverstream shortly before reaching Salisbury's,

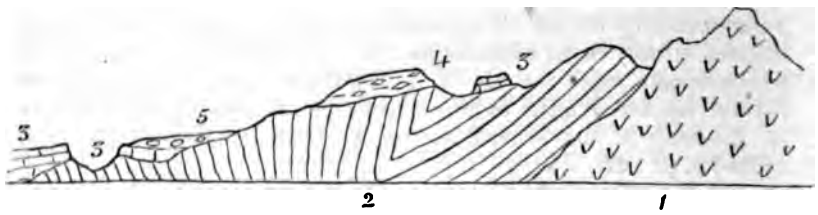
and in a road-cutting there the lower calcareous sandstones yield a great variety of fossils, *Pecten hochstetteri*, *P. hutchinsoni*, *Cucullæa*, *Struthiolaria*, *Cardium*, *Modiola*, *Turritella*, *Perna*, *Dosinia*, *Panopæa*, *Lima paucisulcata*, *Turritella bicincta*, *Flabellum circulare*, *Schizaster rotundatus*, *Balanus*, *Tellina*, *Lucina*, *Calyptræa*, and *Bryozoa* being amongst the number.

They become marly in their lower beds, the whole series, however, being of no great thickness, and rest unconformably upon the schistose rocks. A small patch is again seen at the back of Mr. Cook's house on the Quartz Ranges, being here unfossiliferous, but yielding some of the most beautiful aragonite and calcite crystals which can be imagined. There can be no doubt in correlating these beds throughout the district, and they appear to be the same as those found in the Kaipuke Cliffs, and the fossils bear a striking resemblance to the collections made at Raglan from the Aotea sandstone.

Pliocene Beds.

These are represented in this district by certain auriferous washes, which have not been deposited under the same conditions as at present prevail.

The Quartz Ranges offer the best illustration of this formation, which is shown in the following section :—



Section from Lead Hill through Quartz Ranges to Aorere River. 1. Granite. 2. Slates. 3. Limestone and calcareous sandstone (fossils). 4. Auriferous drifts of Quartz Ranges. 5. Recent river-gravels.

Dr. von Hochstetter describes this locality in his Geology of New Zealand, p. 89, in the following words: "The whole region of the eastern side of the Aorere Valley, rising from the river-bed towards the steep sides of the mountains at an inclination of about 8°, and occupying, from the Clarke River on the south to the Parapara on the north, a superficial extent of about 40 English miles, is a gold field. Throughout this whole district on the foot of the ranges we find a conglomerate deposited on the top of the slate rocks, reaching in places a thickness of 20 feet. Where a ferruginous cement binds the boulders and the gravels together this conglomerate is compact; in other places only fine sand lies between the larger stones. Quartz and clay-slate boulders are the most commonly met with."

With regard to the characters of the formation nothing further can be added, but as relates to its extent I think Dr. von Hochstetter has possibly rather over-estimated it, seeing that, although this formation can be traced for the distance in patches, yet it is only in patches: besides this, its lateral extent is in reality only small, and the apparent width is by no means to be relied on, as with a slope like that which exists a very limited width of washdirt would soon strew boulders over a great width of country; and the basement rock being visible at many places, with no stratified deposits on it, renders it a matter of certainty that such has been the case.

It appears probable, following the line of this deposit, that it was originally brought from the direction of the Gouland Downs, the river which deposited it flowing at a much higher level than that taken by the Aorere now. It was, moreover, in all probability, fed by glaciers, so that the rocks may have been brought from a considerable distance; the fact that quartz forms the principal constituent of the gravels being accounted for by its resistance to disintegration compared with the comparatively soft rocks with which it was associated. That these gravels were brought from a distance, and in no way derived their origin from the immediate vicinity, is, I think, sufficiently borne out by the fact that granite is practically unrepresented in the wash, while the granite mass of Lead Hill cannot be more than two miles distant in a direct line. A similar state of things is represented by the old gravels in Glengyle Creek and Richmond Hill, which were undoubtedly deposited by the Parapara while it flowed at a much higher level than at present; and the Waingaromumu diggings offer yet another instance of this ancient series of river-gravels.

Recent and Pleistocene.

The last-mentioned beds have been cut through by a lateral drainage during recent times, the result being, as with the Tuapeka cements, that the gold has been concentrated by natural means in these cross-channels, which are sometimes only cut in the older cemented gravels themselves, and are at others down to the schistose bed. Very rich gold diggings have been worked in these areas of cross-drainage, and it is, doubtless, from these that the Aorere has, to a large extent, derived its gold. At the Parapara there has been a recent alluvial wash as well as the one which stretches from the Quartz Ranges, and it is possessed of entirely different characters. The sorting and rearranging process has also been carried on here, and there are beds of wash which partake of a mixed character. It must not, however, be understood that the whole of the gold in the Collingwood district owes its origin to these older drifts, for, as I have previously pointed out, all the beds of the rivers which take their rise in

the Te Anau series are more or less auriferous, and a large and important field covered by these rocks has yet to be prospected for the reefs which have yielded the gold to supply these river-beds.

GEOLOGY OF THE WAITAKI VALLEY AND PARTS OF VINCENT AND LAKE COUNTIES.

REPORT BY ALEXANDER M'KAY.

MEMORANDUM OF INSTRUCTIONS FOR MR. MCKAY.

16th September, 1880.

I WISH you to proceed south to carry a section from South Canterbury to the West Coast, taking as much width of country as is requisite for tracing the relations of the formations. Keep the line of section to the north of the Waitaki as far as the Ahuriri formation; thence follow the Lindis Pass, and examine the district of the Hawea Lake, and cross the mountain from the head of Lake Wanaka by Haast Pass. You will pay special attention to those points which I have mentioned verbally to you.

JAMES HECTOR.

NARRATIVE.

5th April, 1881.

I HAVE the honor to report that, for the purpose mentioned in the memorandum of instructions received, I proceeded to the South Island on the 21st September last.

From Christchurch I went to West Oxford to further examine the chalk deposit at that place, and ascertain the nature of the underlying rocks belonging to the same series. There and at the Malvern Hills I was engaged till the 3rd October.

On the 5th October I left Christchurch for South Canterbury, and was employed within the watershed of the Waihao River till the end of the month. During the month of November I was employed in examining and collecting from the rocks of the Waitaki Valley, my attention being principally devoted to that part of it which lies between the junction of the Maerewhenua River and the Upper Waitaki Plains.

Passing from Omarama along the eastern base of the Quailburn Ranges to Lake Ohau, the month of December was spent amongst the mountains lying to the west of the latter locality and in the direction of the western sources of the Hopkins River. Having returned to Omarama I passed through the Lindis Pass on the 31st December, and went to Pembroke, on Lake Wanaka, arriving there on the 5th January. The remainder of the month and the first week of February were devoted to the district lying west of Lake

Wanaka, and towards the sources of the Matukituki, west of Mount Aspiring.

REPORT.

The original object of the trip, as expressed in the memorandum of instructions received, was the collection of facts available for the construction of a detailed section of the different formations exposed along a line beginning on the East Coast near the mouth of the Waitaki River, and thence carried north-west to the West Coast between Jackson's Bay and the mouth of the Haast River.

The early part of the season not being suitable for an examination of the high mountainous country which would have to be passed through when the western part of the district was reached, the first three months were devoted to an examination of the rocks of South-eastern Canterbury and those parts of Otago lying within the Waitaki watershed. In this part of the district Tertiary rocks naturally received a large amount of attention, and considerable collections of fossils were made from rocks on both sides of the Waitaki River.

During the latter part of the season the original plan was somewhat modified so as to enable me to join Mr. Buchanan in the Otago Lake District, and in consequence of this diversion from the original intention my work terminated in making junction with last year's work in the district north and west of Lake Wakatipu.

In this manner a long narrow strip of country was examined, in mapping which I have found it convenient to divide it into a series of blocks, to which reference will be made by the number borne by each.

In the classification on the next page of the rocks met with, the designations and ages assigned to the different formations are, as far as available, those of the latest Geological Survey classification.

I. AND II.—ALLUVIAL AND GLACIER DEPOSITS.

Alluvial Deposits.—It is not necessary to give a lengthened or, except in some particular cases, a detailed account of these beds. Map No. 1 shows their extent in the lower part of the Waitaki Valley, where they form the Papakaio Plain, and the plain north of the Waitaki, between that river and the lower part of the Waihao. High-level gravels cap the Maerewhenua limestone, and form rich alluvial table-lands south of that river: these, however, may possibly belong to a date older than any that can rightly be considered under this head.

The valley of the Waitaki below the Hakateramea junction being yet of a considerable width, a corresponding breadth of shingle-plains is shown along the banks of the river. Further up the Waitaki Valley, from the importance of the underlying rocks, the alluvial deposits are not in all cases shown, but they form a plain three miles long, extending south-east from Wharekauri. At this

TABLE OF FORMATIONS.

Age.	Formation.	Principal Areas of Development.
I., II. Recent to Pliocene	Alluvial and glacier deposits ...	Wide-spread throughout the district.
IV. Lower Miocene ...	Pareora formation.	
	a. Gravel and sands, with lignite beds	Wharekauri and Gibson's Run, Waitaki Valley; Upper Waitaki Plains; near Lake Wanaka.
	b. Pareora clays	Between the Waihao and Waitaki Rivers; Hakateramea Valley; Waitaki Valley, near Station Peak.
V. Upper Eocene ...	*b.* Hutchinson's quarry-beds ...	Wharekauri, Waitaki Valley (greensands full of *Waldheimia triangulare*).
	c. Otakaika limestone = nummulitic limestone	Middle part of the Lower Waitaki Valley.
	d. Kekenodon beds	Middle part of the Lower Waitaki Valley.
VI. Cretaceo-Tertiary	*a.* Grey marls	North bank of the Maerewhenua River, Waitaki Valley.
	b. Ototara limestone	Waitaki Valley, Black's Point to Otakaika River; Waihao River, Canterbury.
	d. Chalk-marls=Amuri limestone ...	Lower part of Waihao River, Canterbury.
	e. Marly greensands	Waihao River, Canterbury; Waitaki Valley, near Wharekauri.
	f. Island sandstone	Waihao River, Canterbury; Waitaki Valley, Black's Point to Wharekauri.
	g. Coal-beds	Waihao River, Canterbury; south side of Waitaki Valley, Big Hill to Maerewhenua.
X. Trias	Wairoa Series	These beds, which I have not been able to distinguish separately, occupy a considerable tract of country to the north of the Waitaki River, within the Canterbury District.
XI. Permian ...	Kaihiku Series	
XIIA. Carboniferous ...	Maitai Series	Waihao River, Waitaki Valley, Quailburn Ranges, and mountains west of Lake Ohau. Both formations are mapped together, as the boundaries could not at all times be determined.
XIIB. Upper Devonian	Te Anau Series	
XIII. Lower Devonian	Cecil and Walter Peak Series ...	Highly-altered slates and sandstones forming subschistose rock, Mount Domett and Kurow Mountains.
XVI. Foliated schists ...	*a.* Middle schists	Shotover Valley to Hector's Col, Mount Aspiring.
	Including Black Peak schists ...	Black Peak, Fog Peak, and Mount Avalanche, Matukituki Valley.
	c. Lower schists	Neighbourhood of Lake Wanaka, Clutha Valley.

point they are of more than ordinary interest, as they contain numerous blocks of fossiliferous Triassic and Permian rocks, which have not as yet been traced to their source. Above Wharekauri, till reaching the Upper Waitaki Plains, although here and there of considerable extent, the alluvial deposits require no special remark.

Crossing the Ahuriri Saddle, which leads from the valley of the Waitaki into that of the Ahuriri River, an alluvial plain is reached, which has evidently once been the bed of a lake now drained by the deepening of the gorge through which the river flows to join the Waitaki. At its upper end, a low range of hills so narrows this alluvial tract that it is nearly shut off from connection with the great extent of level ground known as the Upper Waitaki Plains.

These plains, composed of well-rounded river-gravels, form an extensive area within the Mackenzie country. From the Ohau branch of the Waitaki they extend for a distance of twenty miles in a south-west direction, terminating at the point where the Omarama Stream leaves the mountains, five miles south of the Ahuriri Upper Gorge. The average breadth of this part of the plain is not more than four miles, as all the country stretching north-west from the low hills south-west of Ben More Station to Lake Ohau is covered by glacier deposits.

The rivers falling into the upper end of Lake Ohau have reclaimed as alluvial land six miles of its original upper part. Within the last fifteen years, the mouth of the united Hopkins and Dobson Rivers has been carried forward, by means of the shingle poured into the lake, a distance of about half-a-mile.

In the schistose country lying west of the Waitaki watershed, recent shingle deposits are unimportant till the Clutha Valley is reached. From the Lindis junction to the commencement of the terrace plains, at the foot of the Hawea and Wanaka Lakes, the terraces on either bank of the Clutha are composed of well-worn schistose material; but, over the greater part of the extensive plain between the united branches of the Clutha and Lake Hawea, examination shows that a thin skin of river- or lake-shingle overlies and hides glacier deposits which form the bulk of the material composing these plains.

Falling into the south-west part of Lake Wanaka, the Matukituki River flows for the last twenty miles of its course along an alluvial valley two to two and a half miles in breadth, carrying forward in the upper part of its course an immense amount of shingle. Much of this, from its fragile nature, is so comminuted before reaching the mouth of the river that it is carried into the lake as matter in suspension. The consequence is that, compared with the size of the river, the amount of reclamation effected at its inlet to the lake is comparatively trifling.

In the valley of the Cardrona River, there are in places con-

siderable accumulations of a highly-calcareous marl, which, I learned through Mr. Stone, a resident in Pembroke, forms an excellent fertilizer of the land, and, as such, is being used to a considerable extent. The only deposit of this kind which I had an opportunity of examining is situated west of Lake Wanaka, at the foot of Roy's Peak. In this locality, there intervenes between the high range and the present shore of the lake a narrow belt of broken hilly country, the depressions in which are often swampy, or form the beds of small lakes or lagoons. Near one of these marshy lakes, situated close under the higher range, and 150 feet above the level of Lake Wanaka, there are two or three low hills, composed entirely of the calcareous deposit already mentioned. The space covered by this particular deposit may be some five or six chains in length by three chains in breadth. The thickness of the beds I should estimate at not more than 30 feet. The deposit is seen to be stratified, resting horizontally on the underlying rock.

A sample of this marl, analyzed in the Colonial Laboratory, gave the following results :—

Carbonate of lime	91·60
Carbonate of magnesia	2·49
Alumina and iron oxide	·62
Siliceous matter	2·94
Water	2·35
	100·00

Examined under the microscope, it is seen to consist mainly of the broken shells of fresh-water molluscs, with a small proportion of diatomaceous organisms.

Glacier Deposits.—In the Waitaki Valley, glacier deposits are first met with near Wharekauri, where heavy accumulations of angular material, mixed with beds of clay and silt, rest on Tertiary rocks. This deposit is only locally met with in the immediate neighbourhood of Wharekauri. Formerly it would appear to have extended some distance farther down the Waitaki Valley, as its presence is requisite to explain the occurrence of the fossiliferous Triassic and Permian boulders which are met with between Wharekauri and Upper Ferry. It is not intended to convey the impression that these deposits are due to a great extension of the glaciers of the western mountains forming the Southern Alps, as in this case the glaciers probably took their rise from lesser snow-fields, such as might accumulate on the Kurow and Hakateramea Mountains.

Evidences, in the shape of moraines, &c., of a former extension of the glaciers of the main range of mountains are not met with till passing to the north-west side of the low range of hills stretching south-west from the Benmore home station to the Ahuriri

River. It appears that formerly these low hills, composed of Tertiary strata, were continuous as far as the south bank of the Ohau River. The space inside them to the north and west, east of the Quailburn Ranges and south of Lake Ohau, is wholly covered by glacier deposits, forming the terminal moraines of the Ohau glacier. The outlines of the outer of these are much obliterated, but the later-formed, lying nearest to the lake, preserve all their characteristic features. On both sides of the Ohau Valley lateral moraines show as lines of narrow terraces along the sides of the ranges up to 3,300 feet, or fully 1,500 feet above the present level of the lake.

In the Wanaka and Hawea district it might be a difficult matter to determine how far glaciers have filled the Clutha Valley below the point where distinct evidences of their presence are still to be seen. Mention has already been made that the terrace plains surrounding the lower ends of the lakes are composed of glacier-carried materials, partially reassorted by the action of water.

In the lower part of the Matukituki, and on the west side of the lower part of Lake Wanaka, the evidences of glaciers consist principally in the rounded character of the lesser hills which fill the valley and surround the lower part of the lake.

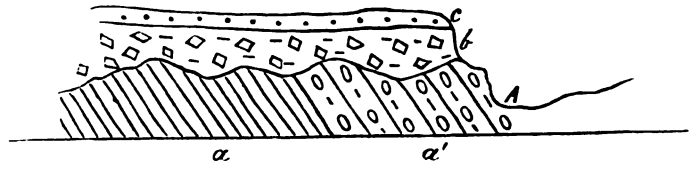
In the valley of the right branch of the Matukituki glacier accumulations are piled to such a degree that they fill to a great depth the whole valley from a point twelve miles above the junction of the two main branches of the river to the source of the right branch. At places the river has succeeded in removing the greater part of these piles of rubbish, but mostly it has not been able to effect more than the cutting of its way through them, and in this manner has formed deep gorges, which, although devoid of rocks *in sitú*, are paved with enormous blocks, and are scenes of exceeding grandeur.

From the absence of morainic material, it appears to be a probable conclusion that the recession of the terminal faces of the glaciers was rapid from the lower end of Lake Wanaka to the point where morainic deposits again show in force in the Upper Matukituki Valley.

With respect to the period when the glaciers acquired their greatest development, a few facts may be stated. Nothing was observed proving that even the oldest moraines are necessarily of greater age than Recent or Pleistocene, although deductions made from another set of facts elsewhere to be observed may show that the greatest extension happened in Pliocene times.

The younger Tertiary rocks met with belong to the Pareora formation, the lower marine portion of which is classified as belonging to the Lower Miocene period. Between the lower and upper parts of this formation I am inclined to believe there is a marked unconformity, and that the coarse gravels with sands and lignite at their base may even be of Older Pliocene date.

On the upturned edges of these latter, the oldest of the glacier deposits are in several places seen to rest unconformably. Upheaval and denudation are thus shown to have taken place before these beds were overlaid in the manner indicated, and, in illustration of this fact, the following section, seen near the junction of the Cardrona with the Clutha, is given,—



Section seen at junction of Cardrona with Clutha River. *A*. Cardrona River. *a*. Pareora beds. *a'*. Higher part, composed of gravel. *b*. Glacier *débris*. *c*. Recent river-gravels.

in which the beds *a* and *a'* represent stratified sands and conglomerates belonging to the upper part of the Pareora formation, tilted so as to stand at a considerable angle, and overlaid unconformably by glacier deposits *b*. Precisely the same thing is seen in the Mackenzie country, between Omarama and Lake Ohau, where an enormous development of Pareora gravels, tilted so as to dip at a high angle, is overlaid by the moraines marking the farthest extension of the Ohau glacier. In the middle part of the Waitaki Valley, near Wharekauri, glacier deposits rest on the same gravels.

IV.—LOWER MIOCENE ROCKS.

Pareora Formation, Upper Part.—These consist of heavy beds of coarse but well-rounded gravels, not infrequently passing downwards into sands and clay with beds of lignite or inferior brown coal. They have a large development in the lower part of the Waitaki Valley, capping with a southerly dip the fossiliferous Pareora beds in the hills between the Waihao and lower part of the Waitaki River. Further up the Waitaki Valley they are strongly developed between the Otakaika and Kurow Rivers, and at Wharekauri are seen to be in connection with the coal-seam worked at that place.

The same gravels are largely developed in the Hakateramea Valley, and at various places from Station Peak in the Waitaki Valley across the intervening hills to Pudding Hill. In the Mackenzie country they are equally strongly developed, and in section much better exposed than elsewhere in the district examined. It is highly probable that these rocks underlie the recent and glacier deposits covering most of the lower grounds forming the Mackenzie country plains. South of the Ohau branch of the Waitaki River they form an isolated hill in the

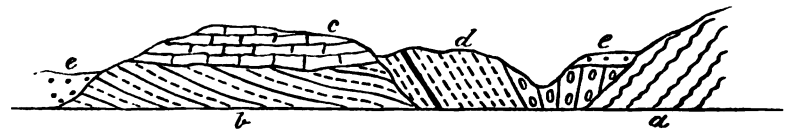
middle of the plain; and six or seven miles from this point, commencing at Benmore home station, they form a continuous chain of hills stretching south-west to the lower end of the upper gorge of the Ahuriri River. Mostly they form hills with rounded outlines, exposing their contents in section only when broken through by such streams as the Quail Burn and Hen Burn; but where the Ahuriri River, after leaving its gorge at the upper end of the Omarama Plain, sets against the base of these hills, a series of almost vertical scarps are produced, which in most cases rise to a height of three or four hundred feet above the plain. These, together with the cross-cuts formed by the small creek coming in at right-angles, show well the alternation of the various strata, and the grain of material composing the beds. In the recessions cut back by the smaller creeks earth-pillars of great height and slender proportions are sometimes formed in considerable numbers, while the parti-coloured highly-inclined strata heighten their picturesque character. Unfortunately, the lowest beds are here covered by the recent shingle of the adjoining plain, but, though less imposing, a better section is exposed along the banks of the Quail Burn. In this section the lowest beds seen are soft sandstones, divided into thick bands by beds of greenish greasy clay. These beds dip north-west at an angle of 45°. In following the section up the creek, the sandstones give place to pebble-beds, still separated by the clay-beds, which at length disappear, and an enormous thickness of gravels, coarsely stratified in thick bands, comes in, dipping to the north-west. These continue until, passing through the range of hills, the whole is overlaid by morainic glacier deposits.

At two or three places along the south-east slopes of these hills pieces of lignite have been found, and near the mouth of the Quail Burn one or two shallow pits have been sunk in the hope of finding the seam, but without success. In examining the section I saw no traces of coal, nor traces of plants indicating its presence; yet, having, as I consider, proved that the Wharekauri coal-seam, further down the Waitaki, occurs in beds of this age, there is more than a possibility of coal being found near the mouth of the Quail Burn.

Gravels, which are probably of the same age as those described under this head, are seen forming high-level terraces on both sides of the lower part of the Lindis River, and the section near the junction of the Cardrona along the west bank of the Clutha shows these beds in a characteristic manner. At Wharekauri the section shown on the next page is exposed, showing that the brown coal worked at that place belongs to this higher part of the Pareora formation.

This section is a sketch of the rocks seen in following up the Wharekauri Creek from its junction with the Waitaki to the old rocks which appear, beyond the coal-seam, on the west side of

the creek. A little further to the south the basement beds of the rocks *d* are seen superimposed on the beds *c*; but in that locality the coal-beds and overlying gravels are obscured by glacier drifts.



Section showing position of coal-seam, Wharekauri. *a*. Subschistose rocks forming the Kurow Mountains. *b*. Wharekauri greensands (Cretaceo-Tertiary). *c*. Otakaika limestone and underlying calcareous greensands (Middle Eocene). *d*. Sandstone with coal-seams, followed by Pareora gravels (Lower Miocene ?). *e*. Recent gravels.

On the opposite side of the Waitaki Valley a small outlier of the beds *d* occurs, resting on the beds *b*, and in the outlier formed of the beds *d* a seam of coal was worked by Mr. Gibson for station purposes, but from its limited extent this was exhausted some time ago.

Both the beds *d* and *b* in this locality being the lower members of their respective formations, and presenting characters somewhat alike, the continuation of this isolated patch of coal-seam was unsuccessfully sought for in the underlying series.

Lower Part, Pareora Beds proper.—This division, comprising the fossiliferous marine portion of the Pareora formation, is chiefly developed in the district examined in the low range which trends south-east from Elephant Hill, separating the Waihao Valley from the lower part of the Waitaki Valley. The same beds are present on the south side of the Waitaki between Oamaru and Papakaio Plain, forming the lower seaward slopes of the hills in that direction.

In their lower beds they consist of sands and sandy clays, passing upwards into marly clays of a light-grey colour. At many places in the middle part of the beds fine-grained blue concretions are abundant, crowded with fossil shells, generally in the condition of casts.

The grey clays and sometimes the lower sandy portion of the beds are highly fossiliferous, and a good collection was made from Mount Harris, the northern slopes of which expose these beds in fine sections; this locality being selected chiefly because from the same place collections now in the Canterbury Museum were made. The variety of species here is not so great as at Awamoa or on the Pareora River, and these latter must still be considered the typical localities of the formation.

In Mount Harris, and for the most part along the same range of hills, the beds dip at low angles to the south.

Near Elephant Hill the beds dip south at high angles, and in part consist of rusty-brown sands with fossiliferous bands between.

At the point where the Waihao River reaches the Seaward Plain the beds are faulted so as to show a westerly dip, and apparently pass under the Cretaceo-Tertiary beds with which they are in contact.

In the Waitaki Valley, five miles below the Hakateramea junction, at the foot of Station Peak, these beds are seen for the last time in following the river upwards. In the Hakateramea Valley, and towards the source of the west branch of the Waihao River, they are to all appearance largely developed, but their examination was not pushed in this direction. Usually these beds rest on some member of the Lower Tertiary or Cretaceo-Tertiary formations; but near Pudding Hill, where they are represented by quartzose grits and brown fossiliferous sands, they rest directly on the older Palæozoic rocks.

At Hutchinson's Quarry and thence along the Seaward Hills to Papakaio Plain these beds rest with apparent conformity on the Hutchinson's Quarry beds. Such also is the apparent sequence in the Mount Harris section. In this the fossiliferous Pareora beds pass downwards into unfossiliferous sands, which may prove to be the equivalents of the Hutchinson's Quarry beds; these in turn resting conformably on the Waihao limestone, the supposed equivalent of the Ototara stone.

At Elephant Hill the junction made is between the fossiliferous part of the Pareora formation and the marly greensands belonging to the Cretaceo-Tertiary series, the higher portion of the latter series having been swept away. At the foot of Station Peak the section appears continuous from the Otakaika limestone to the Pareora gravels. In this section the Hutchinson's Quarry beds do not present their usual characters, and must be considered as merged in the Otakaika limestone.

V.—Upper Eocene Rocks.

a. *Hutchinson's Quarry Beds.*—At no place in this district are these beds developed in the characteristic manner of the type locality, and at Wharekauri only can the beds be recognized by the characters which they exhibit at Oamaru. In this locality they consist of loose dirty greensand, full of shells, followed by grey sands, and they follow the Otakaika limestone conformably. The fossils, though abundant individually, are not numerous as to species. *Waldheimia triangulare,* a characteristic shell of this and the next underlying horizon (the Otakaika limestone), is plentiful, the other forms met with being *Dentalium giganteum, Natica solida, Venericardia intermedia, Pecten hochstetteri, Cucullæa alta* (?), *Limopsis insolata,* &c.

b. *Otakaika Limestone.*—In the Waitaki Valley this limestone forms an important member of the Upper Eocene rocks. Its inferior position to the Hutchinson's Quarry beds, and its foramini-

ferous character, are the grounds for regarding it as the equivalent of the nummulitic limestone elsewhere developed in both Islands. Closely examined, the Otakaika limestone is seen to be a fine-grained highly-calcareous greensand; and the same may be said of the Maerewhenua limestone, which is also a calcareous greensand occurring in the Waitaki Valley. On stratigraphical grounds, however, the Maerewhenua limestone must be regarded as distinct from the Otakaika limestone: the evidence supporting this conclusion will be given further on.

The Otakaika limestone has been examined at three places. First, near the junction of the Otakaika River with the Waitaki, where, resting on subschistose rocks, it forms cliffs bordering the main road leading up the Waitaki Valley. While I was engaged elsewhere, Mr. James Park, by my direction, examined and collected from these beds, endeavouring to make out their relation to the Maerewhenua limestone and underlying rocks. But little evidence of a positive character was obtained; yet it was shown that on the south side of the narrow ridge of schistose rocks, mentioned above, characteristic Cretaceo-Tertiary beds intervened between the older rocks and the limestones north of the Maerewhenua River.

The higher beds capping the Otakaika limestone proved to be gravels belonging to the upper division of the Pareora formation, which would thus overlie the limestone unconformably.

Nearly opposite the junction of the Otakaika with the Waitaki an isolated patch of the Otakaika limestone rests on the older rocks of Lower Carboniferous or Upper Devonian age, forming Station Peak and part of the range north-west towards the Hakateramea. The lowest beds seen are limestones as pure as, though less fossiliferous than, the higher part. Upwards these beds pass into clay-marls resembling the fossiliferous Pareora beds, and the section is closed by a variable thickness of Pareora gravels, and they dip to the westward under the recent gravels of the river-bed, at an angle varying from 30° to 40°.

In the third locality, where seen near Wharekauri, the Otakaika limestone is developed to a greater extent than in the localities already mentioned, showing in places a thickness of fully 50 feet, and is traceable as a continuous line for nearly three miles. Allusion has already been made to this limestone when speaking of the Hutchinson's Quarry beds, which at this place overlie it.

Separated from the out-running spurs of the Kurow Mountains, and having between it and the Waitaki River a level shingle-covered plain nearly a mile in width, the Tertiary rocks form a mountain reaching nearly 2,000 feet above the level of the sea, or 1,000 feet above the river valley at this point. Running along the lower part of the eastern face of this hill, the Otakaika limestone is continuous from Wharekauri Creek to the next large

creek to the south-east. Specially at two places, near the south end of this hill, the limestone forms vertical cliffs of nearly horizontal strata not less than 50 feet in height. In these cliffs, and all along the line of limestone outcrop, fossil shells are most abundant, immense numbers of *Dentalium giganteum* and two large species of *Cucullæa* forming bands at different levels in the cliffs, or, where the hill-slope is more gradual, covering the whole ground with shells in a more or less perfect state of preservation.

In this locality the Otakaika limestone passes upwards into the Hutchinson's Quarry greensands, which are here overlaid by rusty-coloured quartzose gravels, forming a conglomerate cement, not unlike rocks met with at the base of the Cretaceo-Tertiary series. In the higher part of the hill these quartzose gravels are followed by sandstones covered by angular glacier drift. At various places the upper Pareora beds, as coarse well-rounded gravels, rise above or through the glacier deposits, while the presence of loose masses of coal in the slips shows that, as in Wharekauri Creek (not a mile distant), the coal-seams, while underlying the Pareora gravels, at the same time overlie the Otakaika limestone and Hutchinson's Quarry beds. (See section, p. 68.) Both near the junction of the Otakaika River and at the foot of Station Peak, as described, the Otakaika limestone rests on older rocks unconformably. At Wharekauri other beds belonging to the same sequence underlie the limestone, and these, presenting characters which distinguish them, have been separated from the limestone as a yet lower member of the Eocene rocks.

d. *Kekenodon Beds.*—These beds are confined to the Waitaki Valley and the immediate vicinity of Wharekauri. They consist of slightly-calcareous greensand, passing downwards into grey sands and rusty quartzose pebble-beds. With the associated Tertiary rocks they fill an oblong basin striking obliquely across the Waitaki Valley, the length being about four miles, the breadth somewhat less than three miles. Except in the western and north-western parts, where both younger and older rocks are present, the lower Kekenodon beds, conforming to the outlines of the basin, crop to the surface all round its edges, the higher fossiliferous strata filling the central part showing as richly fossiliferous sands on the banks of the river, and, followed westward, they disappear beneath the Otakaika limestone.

The extraordinary abundance of fossil shells and their excellent state of preservation, as seen in the cliffs along the banks of the Waitaki River, makes the locality, on this account alone, a most important one for the collector. The fossils are specifically much the same as those found in the Otakaika limestone, and, except in one case, need not be mentioned more particularly. I refer to the occurrence of the bones and teeth of cetaceous animals in these

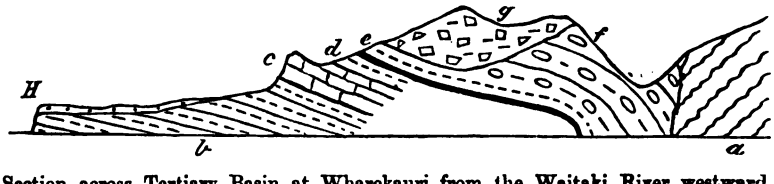
beds. Bones of a cetacean character are not uncommon, but on exposure become exceedingly fragile and are difficult to extract.

At a particular place on the banks of the river where the middle part or lower third of the fossiliferous portion of the Kekenodon beds are exposed so as to be washed by the river when in high flood, remains more than ordinarily interesting were found. Amidst a pile of *débris* (which probably represented an entire head), portions of a lower jaw, with several perfect and numerous fragments of teeth, were found. In excavating such portions as lay beneath the immediate surface, damage unavoidably resulted, so that only the teeth and part of a jaw, as already mentioned, were collected. Lying close to these remains vertebral centra were observed which probably belonged to the same individual. These were planed down by the action of the river so as to show longitudinal sections of the vertebræ. An attempt made to extract one or two of these failed even when a portion of the surrounding matrix was essayed to be taken with the bone.

As seen in section the length of these centra was but little more than their transverse diameter, the articular faces being nearly flat. In length the vertebræ ranged from 3½ to 4 inches.*

In other localities and in the same beds osseous remains were seen, and in one case indications of an entire skeleton were observed. These were not interfered with, as a considerable amount of labour would have been required to secure them.

The following section shows the position of the Kekenodon bed in relation to the Otakaika limestone, also the higher beds connected with the Wharekauri coal-seam:—



Section across Tertiary Basin at Wharekauri from the Waitaki River westward. *a* represents the subschistose rocks of the Kurow Mountains. *b*. The Kekenodon beds. *c*. The Otakaika limestone, including Hutchinson's Quarry beds. *d*. Grits and sandstones associated with the Wharekauri coal-seam. *e*. The coal-seam as seen on the west side of the hill. *e'*. Its supposed outcrop on the eastern slope of the hill. *f*. The Pareora gravels overlying the coal-seam. *g*. Glacier drifts. *H*. The point whence the fossil remains of *Kekenodon onamata* were obtained.

In this section the strata included under *b* and *c* rest unconformably on the marly greensands (Wharekauri greensands) of Cretaceo-Tertiary age, as seen in section at page 64, the unconformity being demonstrated by the absence of the higher part of the marly greensands and the Maerewhenua limestone.

* Such portions of these remains as were in a sufficient state of preservation have been described by Dr. Hector in Vol. XIII. of the Transactions of the New Zealand Institute, p. 486, under the name of *Kekenodon onamata*.

VI.—Cretaceo-Tertiary Series.

a. *Grey Marls.*—The beds which in the Waitaki Valley are considered to belong to this division of the series were neither collected from nor examined on this occasion. On the north bank of the Maerewhenua River the beds so called are seen to rest on the Maerewhenua limestone conformably. This conformity to the underlying limestone, and the character of a majority of the fossils found in them, rather than any resemblance which the beds bear to the grey marls as seen in the Waipara and Weka Pass sections, were the chief reasons for classing them under this head. So far as can be seen they are absent on the south side of the Maerewhenua River, the limestones there being overlaid by heavy gravels of doubtful age. On the north side of the river the fossiliferous beds overlying the limestone are grey sands, with lenticular concretions resembling those found in the Pareora formation, and like these are full of fossil shells.

b. *Ototara or Weka Pass Stone.*—The rocks occupying this horizon are here known by the local names of the Maerewhenua and the Waihao limestones. In 1876 I endeavoured to trace the connection between the first of these (the Maerewhenua limestone) and the Ototara stone, but found that the areas within which each is developed are separated by a breadth of country some five or six miles across, in which not only underlying rocks of the same series come to the surface, but old schistose rocks as well.

Direct continuity being thus interrupted, conclusions as to the synchronism of the limestones in the two localities had to be based upon the character of the rocks, and the fossils obtained from each. The Ototara stone is almost wholly composed of calcareous sands and small coralline bodies; the Maerewhenua limestone is of coarser grain, and contains an amount of greensand that in most cases makes the distinction very apparent.

Except the minute bodies of which its rock-mass is largely composed, very few fossils have been obtained from the Ototara stone. Thus by this means no comparison could be made, although the Maerewhenua limestone proved comparatively rich in fossils, especially in Echinodermata and Brachiopoda. It thus became necessary to prove the relationship of the beds underlying the limestones in the two localities. Here again the tufas of the Waireka Valley differed considerably from the grey sands and marly greensands underlying the Maerewhenua limestone, and, while in the latter locality the beds proved highly fossiliferous, fossils were wholly absent in the beds underlying the Ototara stone, so that in this case also identity could not be proved by means of the fossil contents of the beds. However, stratigraphical connection leaves no doubt on this point. In either locality the limestones are conformable to the beds which underlie, and these, proving to

be the equivalents of each other, prove also the synchronism of the Ototara and Maerewhenua limestones.

The distance separating the Waihao and Maerewhenua limestones is greater than between the latter and the Ototara stone; yet the Waihao limestone has a much closer resemblance to the Maerewhenua rock. The fossils of the two localities are, to a large extent, the same, and the lower part of the section in each case leaves no doubt as to the identity of the overlying calcareous rocks.

The Maerewhenua limestone, as a long line of cliffs 40 feet to 60 feet in height, bounds the Waitaki River Valley for the first three miles below the Maerewhenua junction. Obscured by younger beds, it is present over a large area between the Kakanui and Maerewhenua Rivers. North-west of the latter river it extends a distance of three miles, and terminates as a long line of cliffs, from beneath which the underlying greensands and coal rocks make their appearance.

In the Waihao Basin, the limestone in the same manner appears along the banks of the river, as high cliffs, for a distance of three miles, but no breadth of exposure is seen, the beds being closely overlaid by the lower part of the Pareora formation. From the Waihao Forks this scarp follows the westerly branch of the river for some distance, till, the river turning more to the north, the limestone strikes along the slopes of the hills westward, in the direction of Elephant Hill. Outliers of this limestone are found at three places north of the main line of outcrop, the largest and most important of these being severed from the main line by the action of the river within recent times. This principal outlier begins on the northern branch of the river, a short distance below the forks, and, presenting a line of vertical cliffs on the river-side, extends eastward or down the river a distance of fully a mile. Between these cliffs and the immediate river-bank, a distance varying from a few chains to a quarter of a mile, immense blocks of limestone are scattered at short distances from each other, or piled close together in the greatest confusion, and from these and the adjoining cliffs the fossil collections were obtained. These, like the collections from the Maerewhenua limestones, consist chiefly of Brachiopoda and Echinodermata. A few forms are peculiar, not having been collected elsewhere, whilst others are in a better state of preservation. Amongst these, a large form of *Cidaris* may be mentioned, to which may be referred the large radiately-fibrous spines found in the Maerewhenua limestone, the Curiosity Shop beds, and elsewhere; also a new species of *Rhynchonella*, in outline closely resembling *Waldheimia sulcata*. In this collection there are two specimens of *Scalaria*, which must be regarded as distinct from any of the species of this genus hitherto collected from New Zealand strata.

d. *Chalk-Marls=Amuri Limestone.*—In the Waitaki Valley,

the Maerewhenua limestone is directly underlaid by loose marly greensands, all traces of the chalk-marls being absent. Near Oamaru, the branch railway-line leading into the upper part of the Waireka Valley, where it exposes the beds immediately underlying the Ototara stone, shows the presence of a chalk deposit, very soft, and fine in grain, and wholly composed of remains of exceedingly minute organisms. In softness this deposit rivals the chalk of Oxford, in the Canterbury Provincial District, but is a shade less white, and has a specific gravity considerably less. Its percentage of lime is greater, being 91·17 per cent. as against 82·26 for the Oxford chalk. The amount of siliceous matter and water combined is 6·2 per cent. in the Oamaru chalk, which is thus shown to be superior for the manufacture of Portland cement.

At the base of the limestone cliffs, along the banks of the Waihao River, a grey chalk-marl, about 20 feet thick, shading off downwards into a dark-coloured clay-marl, is present as the next underlying rock. Thin bands of a very dark fine-grained tufa (Palagonite tufa) are occasionally present. Fossils at this point are exceedingly rare, except minute Foraminifera in the lower part of the beds.

Three or four miles further down the river the same beds are developed, under a somewhat different aspect. At this point, where rock is last seen before the river enters upon the alluvial deposits of the coastal plain, the marly greensands are overlaid by dark foraminiferous clay-marls, containing one or two thin bands of decomposed tufa. This is overlaid by a tufaceous fine-grained breccia conglomerate, and this, in turn, by a marly calcareous greensand.

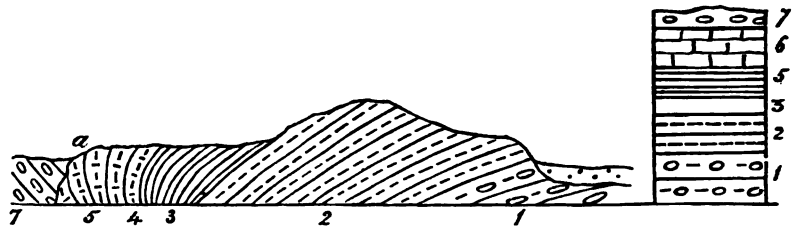
Where these beds rest on the marly greensands they dip east at a comparatively low angle, but the dip rapidly increases, till the breccia conglomerate is found standing almost vertical; and the higher part of the beds have a decided dip in the opposite direction, and are seemingly underlaid by the fossiliferous Pareora beds, which show in the banks of the river a westerly dip.

The peculiarities of this section are no doubt due to a line of fault crossing the river at this point. The sketch-section on the next page shows the position of the chalk-marls; and the vertical section shows the same beds where they are overlaid by the Waihao limestone.

The breccia conglomerate and the overlying calcareous greensands (beds 4 and 5) shown in the section are highly fossiliferous, the variety of species being considerable. *Pecten zittelli* is the most abundant form; while *Sphenotrochus huttonianus*, a coral hitherto found only on the West Coast, in beds underlying the Cobden limestone, also occurs in considerable numbers.

e. *Marly Greensands.*—These, as the next underlying beds, are developed in the Waihao Basin to a considerable extent. Lying

generally at a low angle, they are thus exposed by the removal of the overlying limestone and chalk-marls so as to cover a considerable area, but are again obscured by Recent and Pleistocene river-

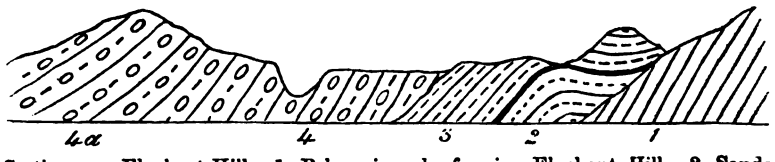


Sections on Waihao River, showing the position of the chalk-marl. 1. Beds immediately overlying the coal-beds at base of the series. 2. Marly greensands. 3. Dark marly clays. 4. Fine-grained tufa-breccia. 5. Chalk-marls in vertical section: calcareous greensands in horizontal section. 6. Waihao limestone. 7. Fossiliferous Pareora beds, apparently passing under the older beds at *a*.

gravels. The beds are usually intensely-dark greensands, and especially near their upper surface contain fossils loose in the sands. Lower in the beds the fossils are usually in concretionary boulders, differing little in character from the surrounding sands. A species of *Limopsis* is by far the most abundant fossil in these beds. A few Gasteropods are also present: some of these, belonging to the genus *Pleurotoma*, closely resemble species found in the Pareora beds at Awamoa, Oamaru. Large specimens of a Nautilus, *Aturia ziczac*, are not uncommon, the larger specimens generally in a fragmentary condition. A fine specimen, 7 inches across and preserving the shell, was obtained from one of the concretionary greensand boulders already mentioned.

For six or seven miles the Waihao River cuts its way through these beds, which, on the river entering on older rocks, strike in the direction of Elephant Hill, where they are next seen in section overlaid by the fossiliferous Pareora beds, without the intervention of the Waihao limestone or the chalk-marls.

As the section of these beds at Elephant Hill is of importance in proving the relations of the Tertiary and Cretaceo-Tertiary rocks, a sketch of it is here given:—



Section near Elephant Hill. 1. Palæozoic rocks forming Elephant Hill. 2. Sands and shales, with coal-seam. 3. Marly greensands. 4. Fossiliferous Pareora beds, overlying 3 unconformably. 4*a*. Higher part of the Pareora formation.

In the section above sketched, the marly greensands terminate at a peculiar fucoidal band, which in the Waihao River is seen to

occupy the middle part of these greensands: the succeeding beds (4) are the characteristic marine part of the Pareora formation, and unconformity is therefore manifest at this point. Not half a mile distant from the point of unconformity represented above, the lower part of the section is complete as high in the series as the Waihao limestone, which is overlaid unconformably by the Pareora beds. On the south side of the Maerewhenua River the marly greensands and coal rocks underlie in direct sequence the Maerewhenua limestone, and at no point do they come in contact with marine Tertiary rocks.

At Wharekauri the section of the younger beds is somewhat complicated; and, from the fact that the Kekenodon beds are themselves a marly greensand, and their unconformity to the Cretaceo-Tertiary marly greensands not being well marked, the two sets of beds may in places be taken to represent the higher and lower parts of the same series.

In the section of these rocks sketched at page 64, the unconformity between *c* and *b* is made perfectly apparent, and is, I believe, exactly as the section would appear provided the obscuring gravels could be cleared away.

The characteristic Wharekauri greensands seen at the bridge on the main road across the creek are on the south bank overlaid by recent gravels, so that in a south direction the immediately-succeeding beds cannot be seen. Following the creek upwards in the direction of the coal-mine, grey marly sandy clays form the higher part of *b* as sketched. *c*, the Otakaika limestone and underlying Kekenodon beds (calcareous greensands), are seen exposed on the face of the hill to the south as nearly horizontal strata, and should therefore rest on both the higher and lower parts of the greensands *b*, thus marking an unconformity between *b* and the lower part of *c*.

At another place on the banks of the Waitaki, a quarter of a mile below the junction of Wharekauri Creek, the Kekenodon beds are seen resting with apparent conformity on the lower part of the Cretaceo-Tertiary greensands as above described. From the absence of the higher part as seen in Wharekauri Creek, this alone would indicate an unconformity between the beds at this point; but apart from this there is a marked distinction in the character of the rocks making junction, and the fossils belonging to the two horizons are very dissimilar.

Usually the Wharekauri greensand is a dark-green fine-grained grit (the little pebbles in which are mostly quartz), followed by the marly beds above mentionod. At the point on the Waitaki River now spoken of, the beds are of finer grain, and of a deep rusty-brown colour, forming a hard rock projecting as a low point into the river-bed. Apart altogether from the fossil shells present, it is easy to recognize this bed as the same horizon which at Elephant Hill is overlaid by the fossiliferous part of the Pareora

formation. Immediately followed as this bed is by the Kekenodon beds, which are in conformable sequence with the Otakaika limestone and younger Tertiary rocks, it is at the base of the Kekenodon beds alone that an unconformity can take place in this section. On the other hand it required but proof of the identity of the Wharekauri with the Waihao greensands to indicate that, in the absence of the Ototara stone and chalk-marls, this junction must of necessity mark an unconformity.

From the marly greensands at Wharekauri a considerable collection of fossils was made. In this is comprised a number of specimens of Crustacea which, mainly belonging to *Harpactocarcinus tumidus*, may, on being worked out, be shown to comprise other forms as well. These Crustacea are all contained in small concretions of greensand, nothing but the concretion itself indicating the presence of the fossil, except it show in abraded specimens; yet in a short time, and within an area not more than 20 yards square, some twenty-five specimens were obtained.

A large Nautilus (*N. danicus?*), the type of which comes from the beds overlying the Brunner coal-seam, was found for the first time on the east coast of the Island in these Wharekauri greensands.

f. *Island Sandstone.*—This rock is represented both in the Waihao and Waitaki Rivers by loose sandy beds, with bands and concretions of hard subcrystalline calcareous rock. (Fossils are rare in the sands, but are abundant in the harder rocks.) Considerable collections were made from this horizon in 1876, from the Kokohu River and at Black's Point, on the Waitaki, and during the present year from the Waihao River. At all three places the fossils are almost identically the same, and differ considerably from those of the overlying greensands (*e*). A small *Cucullæa*, very distinct from the large forms which are found in the Tertiary beds, is the most abundant fossil in the Waihao River, in the hard calcareous sandstones of this horizon. Many univalves and bivalves are associated therewith, most of which belong to recent genera; yet few, if any, of the species are the same as those found in the Kekenodon beds.

g. *Coal-Beds*, forming the base of the Cretaceo-Tertiary series, though not comprising a great variety or thickness of strata, are developed over a greater area within the Waihao Basin than most of the other divisions of the series. But for a distinction in the fossils, the two first, *e* and *f*, might with *g* have been described as coal rocks, seeing that, except where quartz grit is largely developed, the thickness of the three groups *e*, *f*, and *g* does not, on an average, exceed 150 feet. The lowest beds of the coal series are usually quartzose grits, which vary in thickness considerably. Dark shales, with coal, if present, overlie them, and these are often associated with fine white fireclays.

At most places in the Waihao Basin the coal is of very inferior

quality, but at one or two places it has been, or is being, opened out and partially worked. Near the gorge of the main branch of the Waihao some prospecting has been done, and a thick seam is said to have been found a little farther down the river. This latter I did not see, as the drive had fallen in; but on the other side of the river, where the coal crops to the surface, the seam is not more than 4 feet thick, and very inferior in quality.

On the slopes of the hills between the lower part of the western branch and Pudding Hill, coal is also found, and is being opened out with a view to its being worked as a sale pit. At Elephant Hill the coal-seam there is worked only for station purposes.

At Black's Point, in the Waitaki Valley, some prospecting for coal has been carried on in these beds, but without success. The quartz grits there are of no great thickness, and farther up the valley only higher beds are seen under the scarp of the Maerewhenua limestone; but along the western outcrop of the same beds, from the Maerewhenua gold workings to the Otakaika River, the quartz grits are of greater thickness, and in that part of the district are more important on account of their being worked for gold. South of the Otakaika these grits rest on a low ridge of subschistose rock, and the section south is complete to the Maerewhenua limestone. On the northern side the whole of the Cretaceo-Tertiary series is absent, and Tertiary rocks, represented by the Otakaika limestone, rest on the old rocks. The following sketch-section illustrates the position of the two limestones:—

Section showing the relative position of the Otakaika and Maerewhenua limestones.
1. Old rock. 2. Coal-grits and greensands. 3. Maerewhenua limestone.
4. Otakaika limestone. 5. Recent gravels of the Otakaika Valley.

In the section sketched above, the Otakaika limestone is not, as at Wharekauri, underlaid by the Kekenodon beds, but, like the same beds at the foot of Station Peak, rests on the old rocks.

In this district the Lower Tertiary and Cretaceo-Tertiary rocks are not so dissimilar in character as to prevent it being difficult to distinguish between them, or their being grouped together as members of one formation. The Oamaru formation of Professor Hutton includes the Hutchinson's Quarry beds and the underlying rocks to the base of the Cretaceo-Tertiary series, and his classification is followed by Professor von Haast in his Geology of Canterbury and Westland. In a former report (Geological Reports, 1876–77, Oamaru and Waitaki Districts), I endeavoured to show that an unconformity separated the Hutchinson's Quarry beds from the Ototara limestone, the first of these being underlaid by vol-

canic rocks, which rest partly on the Ototara limestone and partly on underlying beds. At the same time the evidence was not sufficiently conclusive to show that the Ototara and Maerewhenua limestones were horizontal equivalents, although they were so classed in that report. Again, the correlation of the Otakaika limestone would at first sight appear to be with the Maerewhenua limestone rather than with the sequence of which the Hutchinson's Quarry beds form a part; but the determination of a horizon of Tertiary rocks underlying the Otakaika limestone, and the direct manner in which the latter is overlaid in the Wharekauri section (see p. 68) by the Hutchinson's Quarry beds, proves the distinctiveness of the Otakaika limestone. At Oamaru the volcanic rocks underlying the Hutchinson's Quarry beds have fossiliferous calcareous bands interbedded with them, the fossils in which do not differ materially from those found in the greensands higher in the section.

These volcanic rocks therefore belong to the Tertiary period, and are probably the equivalent in time of the Kekenodon beds at Wharekauri. In the Geological Reports, 1876–77, p. 59, these volcanic rocks are stated to belong to the horizon of the grey marls, and also to be unfossiliferous. In the northern part of the Cape Hills, Oamaru, no fossils are found till passing the breakwater, but a few have been obtained near the junction of the tufas forming Cape Wanbrow, on which the lower flöes rest unconformably. North of Oamaru a band of altered limestone was collected from in Limekiln Gully, west of Hutchinson's Quarry; and the fossils obtained resemble those found in the altered limestone at the base of the Hutchinson's Quarry greensands.

X. AND XI.—TRIASSIC AND PERMIAN ROCKS.

These are developed west of Pudding Hill, in the range forming the watershed between the west branch of the Waihao and the Hakateramea River. The same rocks appear to form part of the mountains between the Hakateramea Valley and the Waitaki Gorge, but were not examined in this direction. The higher rocks filling the great syncline between the northern ridge of the Kurow Mountains (Rough Ridge) and the eastern slopes of the Hawkden Mountains are, it is highly probable, of this age. The rocks referred to form Mount St. Cuthbert, near Omarama, and the northern part of Ben More Range. They consist of grits and coarse sandstones interbedded with black slaty shales, and sometimes bands of brick-red slates. In Mount St. Cuthbert these rocks were not found to be fossiliferous, and further down the Waitaki Valley examinations were mainly conducted on the Otago side of the river. The beds were partially examined in the Station Peak Range, where they were found striking in a westerly direction and dipping north. The same beds appear to be present in

the ranges at the back of Gibson's Station, further up the Waitaki, but no attempt was made to examine them in this direction. That rocks of this age are present in the district is proved by the numerous blocks of fossiliferous rock in the recent gravels of the Waitaki Valley. Such fossiliferous boulders are found principally between the Hakateramea junction and Wharekauri, and on the Otago side of the river.

As, till passing the Ahuriri saddle sixteen miles above Wharekauri, rocks of this age are not present on the Otago side of the Waitaki, the inference is that these fossiliferous blocks have been conveyed across the valley from the mountains on the Canterbury side, probably by ice. In the first creek down the Waitaki Valley, after leaving Wharekauri, these fossiliferous blocks are particularly abundant, of large size, and so little water-worn that when first seen the natural inference was that the parent rock must be *in sitû* in the immediate vicinity. On following up the bed of this creek, beyond where it is formed of Tertiary rocks, only the subschistose rocks of the Kurow Mountains were found *in sitû*, while in the bed of the stream fossiliferous boulders were plentiful to the foot of the range in which the creek takes its source.

The fossils found indicate the presence of both the Wairoa and the Kaihiku series. Species of *Trigonia, Schizodus, Pleurophorus, Ostrea, Spiriferina, Rhynchonella, Athyris,* and one or two fragments of Saurian bones were collected. The two first, *Trigonia* and *Schizodus,* are characteristic of the Triassic rocks of Nelson and Southland; the other forms might all of them come from the Mount Potts Spirifer beds, near the source of the Rangitata.

XIIa and XIIb.—Maitai and Te Anau Series.

Of the area mapped showing the presence of these rocks, it is probable that the greater portion should be considered as covered by Maitai rocks; but, as at places, especially in the eastern part of the district, the rocks closely resemble those of the typical Te Anau series, and at the same time yield fossils which have only hitherto been found in the Maitai slates, I have thought it best to speak of them together as one series. In the eastern part of South Canterbury these rocks form the greater part of the Hunter Hills, east of the Hakateramea Valley. Between Waimate and the lower part of the Waihao River they form an isolated range about 800 feet in height, which bounds the coast plain to the westward.

A narrow gorge leading into the Waihao Valley separates this range from the southern spurs of the Hunter Hills, a narrow strip of Cretaceo-Tertiary rocks also intervening. The rocks in both this isolated range and the southern prolongation of the Hunter Hills are mainly coarse grey very hard sandstones, slaty breccias, and dark-blue, almost black, slates. The strike of the beds varies

considerably, as a rule a little to the west of north, the dip being westward at angles 60° to 85°. At various places in the more slaty beds indications of fossils were discovered, but further than numerous fragments of a fibrous shell allied to *Inoceramus* nothing could be determined respecting these.

Passing westward to the gorge of the main branch of the Waihao River, these sandstones, slates, &c., are followed and apparently overlaid by red and pale-green breccias, greensandstones, and grey cherts: the latter are in places highly decomposed, forming a soft white rock which resembles chalk.

The green breccias are more or less calcareous, and in places highly pyritous. A specimen of the more pyritous breccia analyzed in the Colonial Laboratory yielded distinct traces of gold. These rocks strike nearly north and south, and pass obliquely across the southern end of the Hunter Hills. To the southward they are not seen beyond the gorge of the river.

In the west branch of the Waihao they are overlaid by sandstones and dark slates striking E.N.E., and dipping to the north, which may belong either to the same series or to the younger Permian rocks.

West of the Cretaceo-Tertiary rocks, in the Waihao Basin, the Maitai and Te Anau rocks form Elephant Hill, their eastern boundary striking thence south to the Waitaki River, where in the rocky bluffs facing the valley the dark slates are well seen. From Elephant Hill to the junction of the Hakateramea with the Waitaki these beds gradually lessen in the breadth of their exposure from five or six miles to less than three. At the southern foot of Station Peak the rocks are sometimes conglomerates, followed by micaceous sandstones with plant-remains. In the same quarter, and near the junction of the Hakateramea, the slates are of a calcareous character, and frequently contain broken *Inoceramus* shells. Except in one instance, none of these were perfect enough to indicate the outline of the shell. The specimen in question showed as a cast on a face of slate *in situ*, and exhibited concentric plications and a wide and straight hinge-line. In the attempt to extract this it was so broken that it could not be restored. However, I was fully satisfied that the shell belonged to the same species which occurs in the Maitai slates near Nelson.

Not till passing the Hakateramea junction are these rocks seen on the Otago side of the Waitaki River. A mile beyond the junction of the Kurow River they form, on the Otago side of the Waitaki, a tract of hilly country four miles long by three in breadth, the rocks being mostly sandstones and dark slates, the latter in places having abundance of *Inoceramus* shell-fragments. The strike in this locality is north-west, or nearly parallel to the river valley. Along the bed of the river the beds form an anticline dipping north-east on the Canterbury side, and on the Otago side

in the opposite direction, for half the breadth of their exposure on that side of the river. Beyond this, along the south-western boundary of the beds, the dip is again to the north-east at high angles. The junction between these and the subschistose rocks forming the Kurow Mountains is obscured by Tertiary rocks.

Two miles below Wharekauri the Tertiary and Cretaceo-Tertiary rocks fill the low ground of the Waitaki Valley, and the Maitai and Te Anau rocks are consequently hidden. Half a mile above Wharekauri they again show on the Otago side of the river, but as a narrow strip only, and almost obscured by recent gravels.

On the Canterbury side of the river this series is present in the hills between the Hakateramea and Gibson's station, forming a narrow belt along the north side of the valley, overlaid to the north-east by younger rocks. A little above Gibson's Ferry these rocks again show on both sides of the Waitaki Valley, and on the Canterbury side form the ranges east of the Waitaki Gorge. On the Otago side of the gorge they form the eastern base of Ben More Mountain and Totara Peak, and continue down the valley to their junction with the older rocks of the Kurow Mountains opposite Gibson's. Forming the lower northern slopes of the Kurow Mountains, their boundary strikes south, south-west, and north-west along the west slopes of the range, and along the Hawkdun Mountains to the source of the Omarama Stream; thence they form the eastern slopes of the northern part of the Mount St. Bathans Range as far as the Ahuriri River. The boundary thus traced is semicircular, open to the northward, the middle space occupied by Mount St. Cuthbert being Permian and Triassic rocks.

From the northern slopes of the Kurow Mountains, north-west to Long-Slip Creek, where the Maitai and Te Anau series rest on schists, the arrangement in section is as a syncline. North of the Ahuriri River the same rocks form the Quailburn Ranges and the mountains immediately west of Lake Ohau, the boundary between these and the schists striking N.N.E. till it reaches the Hopkins river-bed twenty miles above Lake Ohau. Along this western boundary the rocks belong to the Maitai series. As grits and sandstones they are seen dipping east in the lower part of Long-Slip Creek. West of Lake Ohau they strike north and south, and form an anticline, and west of that a syncline. In the side creeks feeding the Hopkins there is an absence of the syncline mentioned, and the rocks forming the western wing of the anticline appear to pass under the schistose rocks with which they make junction.

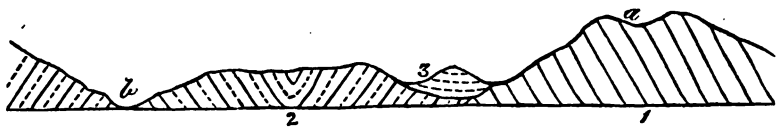
West of Lake Ohau many of the sandstones are full of plant-remains carbonized so as to form in places beds of impure graphite. Stem-like impressions of plants are plentiful up to six or eight inches in length, but never show structure, only a thin vein of bright coaly matter. In the same bed the fossil annelid of Mount

Torlesse is moderately plentiful, which may be considered as proof of the age of the beds, the fossil and the beds in which it occurs being admittedly of Carboniferous age.

XIII.—LOWER DEVONIAN (?).

Cecil and Walter Peak Series.—These rocks form the Kurow Mountains and Mount Domett as far as the country was examined westward in that direction. The beds were examined along two lines of section—first, along the valley of the Awakino Creek, three miles north of the Kurow River; and, secondly, near Wharekauri, six miles higher up the Waitaki Valley. Along both lines of section the beds were observed to dip west at high angles. On neither line were the highest beds reached, the formation being of great thickness. The rocks are highly-altered breccias, sandstones, and slates, identical in character with the Cecil and Walter Peak series of last year's report on the district west and north of Lake Wakatipu. In the Kurow Mountains some of the more slaty rocks are truly schistose, while the more refractory materials, the breccias and sandstones, are still easily recognized as such, their position in the sequence apparently not affecting the condition of the beds, comparatively unaltered sandstones and breccias both underlying and overlying the more schistose slaty rocks which occur throughout the formation.

West of the Otamatata these rocks were not observed, the Maitai and Te Anau series in Long-Slip Creek resting on schists foliated with quartz. Along the junction seen in the upper part of the valley of the River Hopkins, the Maitai rocks have suffered alteration for a short distance east of the line of junction, and there, in some degree, resemble these rocks; but this alteration affects the beds only where they appear to underlie the schists, and where they plainly overlie they retain their normal condition right to the line of junction as seen in the hills east of the approach to the Lindis Pass.



Section across the Waitaki Valley, near Upper Ferry. 1. Kurow schists, or Cecil and Walter Peak series. 2. Maitai and Te Anau series. 3. Tertiary rocks. *a*. Kurow Mountains. *b*. Waitaki River.

That these rocks unconformably underlie the Maitai and Te Anau series, or the rocks described in this report as such, is shown by the manner in which the younger rest on various portions of the older series. Between the Kurow and Wharekauri actual junction was not observed. The above section nevertheless indicates unconformity pretty plainly.

XVI.—Foliated Schists.

These extend from the east side of the Lindis Pass to the western boundary of the district. The lower foliated schists are met with in the Clutha Valley, and form the mountains on either side of Lake Wanaka. Their central axis appears to pass through Glacier Dome, north-west of Lake Wanaka. Along the boundaries of the formation the beds dip to the south-west and north-east, forming an anticline running north-west and south-east. The central part of this broad anticline undulates in the direction of the main strike. From the main chain north-west of Lake Wanaka the dip is south through Mount Alta to the mouth of the Matukituki and the low hills north of Roy's Peak. In Mount Iron, at the foot of Lake Wanaka, the dip changes to the north, and, following down the Clutha Valley, lower beds are continually being reached till passing Cromwell at the junction of the Kawarau with the Clutha. On the east side of the Clutha Valley, above the Lindis River, the lower or foliated schists may extend some six or eight miles, but do not occur in the Lindis Valley, where it follows a north-and-south course. Along the middle part of the Lindis Valley, and east to the eastern side of the Lindis Pass, the rocks belong to the middle division of the foliated schists; but underlying these, and dipping to the westward, schist with considerable quantities of quartz makes its appearance in the hills on either side of the middle part of Long-Slip Creek.

It may be that these rocks are not the same as the contorted lower schists forming the axis of the great central anticline, but they underlie the soft blue mica-slates which along the Lindis Valley rest on the contorted schists.

The rocks in question stretch south from the east side of the Lindis Pass in the direction of Mount St. Bathans, which is thus probably formed of them. Northwards they extend past the sources of the Ahuriri River, and in that direction, yet further to the north, are found within the watershed of the River Hopkins. Fifteen miles above Lake Ohau a large stream joins the Hopkins from the west, rising in the range which strikes south from Mount Ward to the source of the east branch of the Ahuriri River. For the first two miles west of the main river-bed this stream cuts through Maitai slates and sandstones, dipping west at high angles. These are followed by dark-blue slaty rocks and granular and fine-grained chloritic schists, full of lenticular masses and veins of quartz. Beyond these, on the western slopes of the same block of mountains, pink talcose schists dip west and pass under the mass of Mount Ward, at the source of the Hunter River. With these are bands of grey cherty quartz, which contain considerable quantities of manganese ore and small quantities of copper. The compact green rocks are sometimes associated with or pass into a brown ferruginous rock, and both in these and the quartz veins

crystals of copper-pyrites and specular iron are not uncommon. Gold has been obtained both in the beds of the creeks and from quartz-veins in these rocks, but as yet in quantities too small to pay for working.

West of Lake Wanaka the lower schists form the Mount Alta Range, east of the Matukituki Valley, and are there broken through by various intrusive rocks, generally of a basaltic character. These dyke rocks generally strike in a direction between west and north-west.

Middle Schists.—These, as soft blue or grey mica-slates, are seen east of the central anticline in the valley of the Lindis River, and reach east to the Lindis Pass. Their general dip is to the east, but along their eastern boundary they dip in various directions between east and north, these changes being frequent and occurring within short distances. On the west side of the Matukituki Valley the lower schists are overlaid by a series of rocks peculiar to that part of the district. These, forming the greater part of Black Peak, are well seen along the eastern slopes of that mountain, and in Fog Peak lying to the northward. The lowest beds consist of a fine-grained crystalline rock resembling syenite, which seen in mass appears to be stratified. This rests on the lower schists unconformably, and is conformably overlaid by grey and bright-pink micaceous quartzites 500 to 600 feet thick. The quartzites are followed by a soft grey granular mica-schist which is apparently of great thickness, the highest peak of the mountain, fully 7,000 feet above the level of the sea, being composed of this rock. On the eastern slopes of Black Peak these rocks dip west at moderate angles; near the top of the peak they are almost horizontal. On Fog Peak they dip more to the south-west, and the beds are not reached on the northern spur till the higher part of the mountain is attained. They cannot be traced across the west branch of the Matukituki; but, from the pink quartzites forming part of the shingle of the east branch, they appear to pass along the eastern slopes of Mount Avalanche and Mount Aspiring. On the western sides of Black Peak and Fog Peak the dip of the strata increases to an angle of 45°; and as the section is followed west all the beds dip in that direction, and apparently overlie the Black Peak rocks. Little or no quartz is met with in these rocks, which, crossing the west branch of the Matukituki, strike north, forming the higher parts of Mount Avalanche and Mount Aspiring. Towards the main chain, west of the upper part of this branch of the Matukituki, granular chloritic schists containing magnetite come in, still dipping west and overlying the soft mica-schist further east. At the far source of the river a thick band of compact green rock, dipping west at an angle of 45°, is overlaid by soft mica-slates, which latter weathering rapidly leave the green rock as a smooth sloping face on the one side of the approach to Hector's Col, while on the other hand the slates,

as perfectly inaccessible precipices, admit of no other approach to the saddle than along the bottom of the narrow ravine thus formed.

The green rock strikes directly across the Col itself, and forms on the western side a smooth sloping face three times the depth of that on the eastern side, down which lies the only practical means of reaching the west side of the range.

Seven miles from its source the west branch of the Matukituki divides into three nearly equal streams. That which strikes west rises in the main range opposite the source of the west branch of the Shotover, and, judging by the material brought down by it, the rocks at its source are in no way different from those in the vicinity of Hector's Col.

Description of Horizontal and Vertical Sections accompanying this Report.

In no straight line of sections can all the rocks of the district be represented; therefore, by preference, lines have been selected which show to best advantage the deeper-seated structural rocks of the country. In this respect a choice lay between the north and south borders of the belt of country examined; for near the East Coast the northern or Canterbury side appeared to me the most important, while in the central part the greatest variety of rock formations lies on the southern side. For this reason the principal section has been drawn obliquely, and on various bearings, across that part of the map representing the Waitaki Valley, and will be described from point to point as lettered.

In its eastern part the main section lettered *a* . . *a'* commences on the coast-line nine miles north of the Waitaki River; and for six miles it shows only recent alluvial deposits, forming the coastal plain. Near the north bank of the Waitaki River these plains are stony, but further to the north the shingle is covered by a loamy soil, forming rich agricultural land. The coarser materials forming these alluvial deposits are almost wholly fragments of sandstones which, derived from the mountains of the interior, have been poured out along the coast-line mainly by the agency of the Waitaki River.

On passing over the coastal plain, the section-line touches the hilly country close to the north bank of the Waihao River, where Cretaceo-Tertiary rocks, representing VI. *f* and *g*, having a southerly dip, rest on old sandstones and slates belonging to the Te Anau or Maitai series, the rocks of which dip at this point in a westerly direction.

These older rocks, across which the line of section runs, form between the Waihao River and Waimate an isolated range separated from the southern prolongation of the Hunter Hills by a deep narrow valley called the Waimate Gorge, which from Wai-

mate leads south-west into the basin forming the middle part of the Waihao Valley. The lowest beds of the Cretacco-Tertiary series rise on the southern end of the range to heights fully 400 feet above the sea, and here, as quartzose grits and dark micaceous coaly shales, are present in the line of section striking nearly parallel thereto, but dipping south in the direction of the Waihao River.

Descending to the west, the section-line crosses the upper part of the Waimate Gorge just before it opens out on the level ground which forms a swampy plain between there and the Waihao Forks. The rocky bluff bounding the deeper part of this gorge exposes hard grey sandstones, fine-grained slaty breccias, and dark-blue slates, dipping W.S.W. at high angles. Rising abruptly, the hills on the west side of the gorge rise to a height of 500 feet. On their western slopes the old rocks are overlaid by the lower members of the Cretacco-Tertiary series, yet not so deeply but that for some distance the older rocks are exposed in the deep gulches cut by the smaller creeks on their way to join the main stream flowing through the gorge.

The younger rocks, here dipping to the westward, form a line of low hills composed of the beds VI. *e*, (Marly Greensands), which overlie the coal grits. Towards the western side of this belt of younger rocks the greensands are capped by calcareous sandstone belonging to bed VI. *b*, which form hills somewhat higher than those formed exclusively of the greensands, and in which the strata lying nearly horizontal sharply abut against the older rocks which lie to the west between here and the left branch of the Waihao River. This second ridge of older sandstones forms the southern termination of the Hunter Hills, which, prolonged between two outcrops of Cretacco-Tertiary rocks, reaches nearly to the Waihao Forks.

In the line of section as chosen, the Tertiary rocks lying south of the Waihao River cannot be shown: their strike, being east-and-west, does not enable them to cross the section-line at any point within the Waihao basin. Their relation to the Cretaceo-Tertiary rocks upon which they always rest has been shown in the woodcut on p. 64, and, their extent being shown on the accompanying map, these it is hoped will be sufficient for their illustration.

The isolated patches of limestone (calcareous greensands belonging to VI. *b*), which cap the marly greensands on the main line of section where these occur between the Waimate Gorge and the left branch of the Waihao River, are the same as that forming the long line of cliffs on the south bank of the Waihao, below the forks of the river. Their isolation from the main body of limestone is due to the denudation of the limestone which once occupied the intervening space. Whilst this was in progress, the river, in the lower part of its course from the forks to the sea, flowed in a

different direction from what it follows at the present time, as there is evidence that a line of limestone cliffs compelled it to turn to the north-east, and to escape from the hills by way of the Waimate Gorge till the set of the stream broke down the barrier which separated it from the deep gorge of a small stream coming from Mount Harris, having done which the course of this stream now forms the channel of the river. The banks of the old river-channel may in places yet be observed, and the drainage from the very edge of the terrace overlooking the Waihao flows in the direction of Waimate.

The limestone outliers in the line of section abut, as has been said, against the old sandstones to the west, and in this respect are peculiar, as everywhere else the limestones of this age have interposed the lower part of the Cretaceo-Tertiary series between them and the older rocks which unconformably underlie them. On the western side of the spur, not a mile distant, the coal grits and greensands are seen resting on the older rocks, leading to the supposition that on the east side of the spur the younger rocks have been faulted so as to bring the limestones in contact with the older rocks. At this place the old rocks consist almost wholly of sandstones, which dip in a westerly direction. Descending the slope of the ridge to the west, the higher rocks making junction with the Cretaceo-Tertiary series are met with as greenish diorite sandstones and flinty chertose rocks, both being frequently in a highly decomposed state, the cherty rock especially being to a considerable depth converted into a soft white rock resembling the fireclays associated with the coal-measures. These decomposed cherty rocks are overlaid by grits and dark shales associated with thin seams of impure coal, these being in turn overlaid by high-level gravels forming terraces on either side of the river.

Following the section westward, before crossing the east branch of the Waihao River, the coal grits are overlaid by dark sulphurous greensands, which, as nearly horizontal strata, underlie the surface gravels, forming the terraces between the two branches of the river. In the western branch of the river these greensands to some extent replace the coal grits, and rest hard on the dark carbonaceous sandy shales which here occupy the position of the coal-seams in the other parts of the district.

Everywhere there is evidence that the lower Cretaceo-Tertiary rocks are at no great depth underlaid by the old sandstones and slates described as belonging to the Te Anau or Maitai series. At one or two places between the two branches of the river these reach the surface, showing sandstones and dark-blue slates, dipping west at high angles. Within the space between the two branches of the river, the Cretaceo-Tertiary rocks must hide from observation a belt of peculiar rocks which, striking in this direction, are exposed in the gorge of the east branch of the river two and a half miles above where the line of section crosses, as already

described. These rocks consist of red and green breccias, closely resembling the typical rocks of the Te Anau series; they are associated with bands of pyritous chert, which yield traces of gold. Through them the river has cut a deep narrow gorge, which at the bottom is not wider than the bed of the stream, and is bounded by vertical cliffs several hundred feet high: this gorge has never yet been passed through, but it is probable that the deeper and narrower part is cut through the same rocks which form its southern end, which may be reached, as when the river is low its bed can be followed for a short distance. The strike of these breccias is a little to the west of south, but they are not traceable in this direction beyond the immediate bank of the river, high-level gravels and Cretaceo-Tertiary beds overlying and concealing them.

Crossing the west branch of the Waihao, some five miles of hilly country are covered by Cretaceo-Tertiary rocks, through which in many places the old rocks make their appearance; and yet further west, where the west branch of the Waihao divides into two streams at Pudding Hill, isolated patches of Tertiary rocks are preserved in the depressions of the older rocks.

From Pudding Hill west to the Hakateramea River the line of section was not followed, and the nature of the rocks is inferred from what was observed near Pudding Hill and on the east side of the lower part of the Hakateramea Valley, the Te Anau and Maitai series being in these places overlaid by younger rocks, which have been referred to the Permian, and, as seems probable, even younger rocks belonging to the Triassic periods. Near Pudding Hill these beds dip to the west, but in the Hakateramea Valley to the north, the change of strike affecting the older Te Anau and Maitai rocks in the same manner.

Along the eastern flanks of the range separating the Waihao from the lower part of the Hakateramea River, Tertiary beds referred to the Pareora formation are present. Heavy deposits of gravels also rest at the foot of the range on the east side of the Hakateramea Valley, which are considered to belong to the gravel formation which at many places caps the marine Pareora beds. The same gravels occur in the line of section at high levels on the west side of the valley, the hills immediately west of which are composed of sandstones dipping to the north, and these, overlying the Te Anau and Maitai series, are regarded as belonging to the Permian or Triassic series. West of this till reaching the north bank of the Waitaki River are a series of gritty sandstones and blue calcareous slates, striking nearly parallel to the line of section and dipping north at high angles. These rocks, which are continuous along the north side of the Waitaki Valley from Elephant Hill to this point, belong to the Te Anau and Maitai series, the evidence supporting the age assigned to them being given in the first part of this report.

Just touching the Lower Tertiary beds on the north side of

the river, the section crosses to the Otago side of the Waitaki Valley one mile below Wharekauri, and in this way intersects one of the most interesting areas of the whole district. On the Canterbury side of the river grey sands and white clays are seen resting on the older rocks, dipping at a considerable angle to the N.W.; and the same beds appear on the Otago side of the river, in places associated with quartzose grits: these are overlaid by greensands developed on both sides of the river, which rapidly lessen the angle of their dip, till the beds become nearly horizontal, and so continue till they are overlaid by the Otakaika limestone in the hill south of Wharekauri Creek. These beds have been determined as Lower Tertiary, and shown to underlie all the Tertiary deposits previously distinguished as such in this district. From these beds, at the point where the section-line crosses to the Otago side of the river, were obtained the teeth and other remains of *Kekenodon onamata* (Hector), a reference to the description of which is given at page 68 of this report. These beds rest, as I have attempted to show, unconformably on the Wharekauri greensands, which, as exposed on the banks of the Waitaki River and in the line of section where this crosses Wharekauri Creek, dip to the south-east, and otherwise in the character of its fossils yield evidence that these latter belong to the Cretaceo-Tertiary greensands. Beyond this point the section is obscured by the recent high-level gravels of the Waitaki Valley; but the gravels and soft sandstone at the base of which lies the Wharekauri coal-seam, though not seen at the surface, are present in the line of section.

Westward of this basin of younger rocks rise the eastern slopes of the Kurow Mountains, in which rocks yet older than any here described are met with. These, as sub-metamorphic rocks described at page 80 under the heading of *Walter and Cecil Peak Series*, form the mass of the Kurow Mountains, and in the line of section, dipping to the west at varying but generally high angles, rise to a height of 4,000 feet above the sea, and further to the south on the same range of mountains to 6,000 feet. These rocks do not in section show as clearly as might be hoped what is the nature of their junction with the old sandstones and slates lying to the eastward, and which have already been noticed as belonging to the Te Anau or Maitai series, but, dipping in opposite directions and differing considerably in character, they have been rightly considered under different heads. Neither in this line of section nor elsewhere were these rocks observed making junction with the foliated schists which, bounding them to the south and south-west, form the central district of Otago. Within the Waitaki watershed, and on the line of section west of the Kurow Mountains, these rocks are overlaid by sandstones and slates which are very similar to those already referred to the Te Anau and Maitai series: these are met with west of the northern

part of the Kurow Mountains, in the valley of the Otamatata River, and, dipping at high angles to the west, continue till overlaid by younger beds on the higher part of the Ahuriri Saddle, and the continuation of the same line north and south. West of this line the rocks are gritty sandstones and fine-grained pebble-beds, sometimes conglomerates, alternating with black and brick-coloured slaty shales, which, although dipping irregularly, usually do so in a W.N.W. direction. These beds form Mount St. Cuthbert, and the hilly country intervening between it and the Ahiriri Saddle. These rocks were examined chiefly along the main road leading to Omarama and on the northern part of Mount St. Cuthbert, and, as the section-line lies a little to the south of this, the rocks may not be shown exactly as they occur.

On the western side of Mount St. Cuthbert the general dip of the strata changes to the east, and once more the Te Anau and Maitai series makes its appearance from underneath the younger rocks forming Mount St. Cuthbert. These are shortly interrupted by the recent shingle of the Upper Waitaki Plains, crossing which the section-line shows the same rocks forming the higher and eastern slopes of the northern continuation of the Mount St. Bathans Range. On the western side of this range, as coarse gritty sandstones, these, the oldest of the unaltered rocks of the district, rest with an easterly dip on schistose rocks dipping at high angles to the west, which, in the approach to the Lindis Pass, first make their appearance in the valley of Longslip Creek four miles from its junction with the Ahuriri River, and, gradually taking the place of the sandstones forming the range to the eastward, these are confined to the eastern slopes of the range for some distance before reaching the Lindis Pass.

The route followed in passing from the Waitaki to the Clutha Valley leading across the Lindis Pass, and thence following the Lindis River to its junction with the Clutha, necessitates an alteration of the direction of the section-line so as to make it as nearly as possible that of the route followed. Consequently, after having reached the schistose rocks in the middle part of Longslip Creek, turning to the south-west, it is continued in that direction till reaching the southern part of the Lindis Peaks, lying between the lower part of the Lindis and the Clutha Valley. On reaching the Clutha Valley the section-line resumes a W.N.W. direction, which is continued to the main range west of the Matukituki Valley as far as the survey was extended in this direction.

From the eastern boundary of the schistose rocks till reaching the Clutha River no diversions were made from the ordinary route followed in making this journey, and therefore the section representing this part shows in but a general way the disposition and relations of the different divisions of the schistose rocks, which, excepting the recent deposits of the Lindis River, are the only rocks present in this part of the line.

The metamorphic rocks lying farthest to the east, as seen in the middle part of Longslip Valley, are grey mica-schists, containing a considerable amount of quartz as a constituent of the rock, over and above the occasional reefs of white or grey quartz which are present in these rocks. The dip of the rocks is to the west at high angles, and the same beds must extend north-and-south for a considerable distance as shown on the map, on which these rocks occupy the area marked No. 15, and are referred to as the "higher part of the lower or contorted schists."

Just as the summit of the Lindis Pass is reached the character of the schists changes, and accompanying this change of character is an alteration of the direction of the dip, which is irregular, varying between east and north. The rocks are now soft blue mica-schists, containing little or no quartz—a fact which is specially noticeable if comparison be made of the shingle filling the creek-beds on either side of the Lindis Pass. Throughout the middle part of the Lindis Valley the scarcity of quartz in the alluvium of the river-banks and in the bed of the river is very noticeable, and shows that the comparatively quartzless rocks are present throughout the greater extent of this part of the valley.

In the mountains west of the middle part of the valley these blue mica-schists make junction with the lower division of the foliated schists which form the western slopes of the range overlooking the upper part of the Clutha Valley. In the line of section as drawn, the actual point of junction was not observed, its approximate position being determined by observations made three or four miles further to the south, where the boundary between No. 14 and No. 16, as shown on the map, is marked by an abundance of quartz in the rocks quite sufficient to distinguish those in the western part of the range from the rocks of the Lindis Valley.

On entering the Clutha Valley the lower or contorted schists forming the great central anticline of the interior of Otago dip to the eastward in the ranges bounding the east side of the Clutha Valley; but along this broad valley recent and glacier deposits occupy the line of section as far as the outlet of the Wanaka Lake. In the banks of the Clutha River, at and for some distance below the junction of the Cardrona, stratified sands and gravels, dipping to the north at a considerable angle, show underneath the more recent accumulations forming the higher part of the terraces. Although observed at this place only, it seems probable that these beds are extensively developed under the higher deposits forming the Terrace Plains stretching from the northern slopes of Mount Pisa Range to the southern end of Lake Hawea.

In Mount Iron, standing a little south of the line of section, the lower schists dip to the north; while in the northern part of Roy's Peak, also south of the line of section, the dip is at low

angles to the south. These undulations in the direction of its strike do not sensibly affect the N.E. and S.W. dip of the lower schists where these, outside of the immediate axis of the anticline, dip at higher angles in either direction, or at least do not do so south of the Lake District. North-west of the southern end of Lake Wanaka, in the Mount Alta Range, the dip of the lower schists is south at high angles, and, subject to local variations, this appears to be the general dip as far as the main range north of Mount Aspiring.

Crossing the lower end of Lake Wanaka the section-line reaches its western shore near the mouth of the Matukituki River, where the valley of that river is occupied by a series of lower hills, of which the rounded outlines, especially of their northern slopes, give evidence that they have been subjected to the action of glacier ice. In these hills, the rocks of which belong to the lower schists, the dip is to the south and south-west at gradually-increasing angles till west of the Motutapu River the same rocks dip at high angles. North-west of these lower hills the section for some distance is carried along the alluvial grounds of the Matukituki Valley till the foot of the low range lying in front of Black Peak is reached: this front range, formed of the lower division of the foliated schists, is separated from Black Peak by a swampy valley. The same rocks as mica-schist, containing much quartz, are well seen at the base of Niger Peak one to two miles to the north, where they form high cliffs, round the base of which a track has been cut, so as to avoid the more swampy portions of this part of the Matukituki Valley. More to the south the section is carried across the north-eastern spur of Black Peak, and passes close under the higher peak of the mountain. At about 500 feet above the level of the valley, or 1,800 feet above the sea, the foliated schists, stretching along the eastern base of Black Peak, are overlaid by bright pink and grey micaceous quartzites, which, forming a wall of nearly vertical cliffs, render the ascent of Black Peak on the east side of the mountain a matter of no little difficulty, and only at one or two points can this be effected with safety. The quartzites rest unconformably upon the lower foliated schists stretching along the base of the mountain, and are from 500 to 800 feet thick. At about the 3,000-feet level they are seen to be overlaid by soft dark-grey mica-schist of a granular structure, which continues to and forms the higher part of the mountain. Apparently chiefly developed at the base of the quartzites, but not well seen in Black Peak, are beds and dykes of intrusive rocks, sometimes appearing as syenites, and in the dykes as a close-grained basaltic rock. Much material of these rocks is carried into the low grounds by the large stream draining the northern slopes of Black Peak, but they seem much more strongly developed on the eastern spur of Niger Peak, where large blocks of the more crystalline rocks have been detached from the precipitous sides of the moun-

tain, and lie scattered along the track leading round its base. On the higher part of Black Peak these rocks are not abundant, but at a height of 5,500 feet a dyke of dark basaltic rock 8 or 10 feet in width was met with, striking north-west and cutting the grey schists vertically. These intrusive rocks are not confined to any particular division of the schists, since on the opposite side of the Matukituki Valley they appear in the lower schists forming the Mount Alta Range, and are met with at all heights up to 7,800 feet, one of these dykes crossing the highest part of Mount Alta.

All the beds forming Black Peak, from the pink quartzites to the highest part of the mountain, 7,500 feet above the sea, dip at low angles to the west; but immediately west of the peak itself the dip is suddenly increased, and in the range to the north-west striking in the direction of the western part of Fog Peak the dip, as judged of from a distance, is about 45°, and in a westerly direction. Although in making the ascent of Black Peak this part of the range was not reached, the estimate of the dip was confirmed by observations made in the same line farther to the north-west; and in the same line north-west of Black Peak the section is carried along the crest of the high range dividing the eastern sources of the Shotover from the valley of the west branch of the Matukituki, which range is studded with a series of rugged peaks, several of which appear wholly inaccessible. At three places this range was ascended to a height of 6,500 feet, and at all points the strata were found dipping at high angles to the west, or a little to the north of west. This dip was observed west to the main branch of the Shotover, and eastward to the range west of Black Peak, in which the high westerly dip has already been noted.

One peculiarity of this western part of the section is the total absence of the intrusive rocks, no trace of these being met with in those creeks feeding the west branch of the Matukituki which are more than four miles up the valley from the junction of the two main branches. Throughout the whole of this western part of the section there is but little quartz associated with the schist, the only exception being a thick band of pyritous quartzose rock occurring on the eastern spur of the high mountain standing between the two principal branches of the Shotover. This rock is very noticeable on the Matukituki side of the range, forming large patches of red shingle at a height of 6,000 feet, to examine which I ascended the range and found that the red shingle was made up of a grey quartzose-looking rock, rather soapy to the feel, and having scattered through it crystals of iron pyrites, which on decomposing stained it a red colour.

The general scarcity of quartz in this part of the district is shown by its forming so little of the shingle in the bed of the west branch of the river. Towards the western end of the section, in the range between the west branch of the Matukituki and the

source of the main western branch of the Shotover, thick bands of hard green schist make their appearance; and in the beds of the glacier streams coming from the main range north towards Hector's Côl these green rocks form a considerable item in the shingle of the mountain-torrents, and form a thick band striking across the main range west of Mount Aspiring. These rocks are nearly in the same geological horizon and strike of the rocks forming the eastern slopes of the Richardson Mountains, east of the Rees River and the upper part of Lake Wakatipu, and thus reach the same rocks which terminated to the eastward the sections accompanying last year's report on the country north and west of Lake Wakatipu.

ON CERTAIN POINTS CONNECTED WITH THE GEOLOGY OF THE AUCKLAND DISTRICT.

REPORT BY S. HERBERT COX, F.C.S., F.G.S., ASSISTANT GEOLOGIST.

Wellington, 30th June, 1881.

BAY OF ISLANDS COAL MINE.

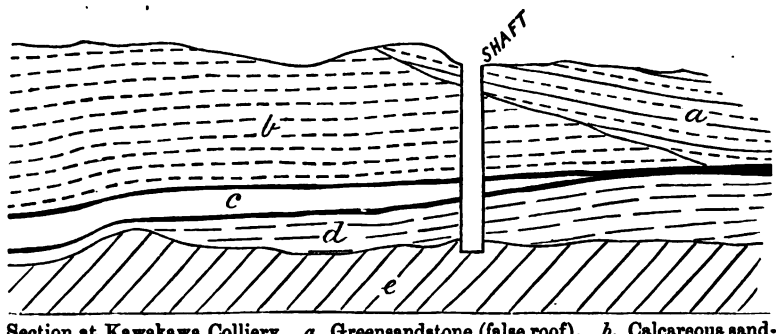
WITH regard to the Bay of Islands Coal Mine the following points will prove of interest. In the sinking-pit the section of the coal is as follows:—

	Ft.	in.
Upper seam	4	3
Hard sandstone parting	7	0
Lower seam	5	9
Mud parting	0	4
Coal	2	9

A hard blue calcareous sandstone, locally known as limestone, forms the roof to these seams.

The hard sandstone parting widens out to the dip, and at about 100 feet from the shaft it is 14 feet thick, with the lower seam 4 feet thick and dirty, while the upper one is only 1 foot 10 inches thick. To the dip again the upper seam comes down with a roll, taking a steady dip once more about 400 feet from the shaft on the same line as the lower coal, which has thinned out to a few inches and been thrown down.

The impression I formed, from what could be seen here, was that the slates come up in a ridge about this point in the mine, and that the coal has thinned out against them, and that when followed farther to the dip it will thicken again as it leaves the slates. The following section will illustrate what I mean:—



Section at Kawakawa Colliery. *a.* Greensandstone (false roof). *b.* Calcareous sandstone. *c.* Coal-seams and parting. *d.* Sandstone and fireclay. *e.* Slate.

Out towards the old workings in No. 7, and east from the new dip, the coal has been greatly troubled, and sometimes the top seam, sometimes the bottom, has thinned. Towards the swamp the coal is much better, but it is not safe to prosecute the workings in that direction.

The main roof of the mine, so far as at present known, is the calcareous sandstone, with *Cardita* (?), &c., at places, but in the old workings a soft greensandstone formed the roof, and ran across from the face of No. 7 to No. 2 shaft, only showing in the sinking-pit at one corner in a small patch.

It appears probable that this greensandstone is unconformably younger than the calcareous sandstone which has been met with as the roof to the dip, and in effect forms a false roof; but I could not satisfy myself thoroughly of its relations to the other beds.

During the past year a great deal of deadwork has had to be carried on at the Kawakawa Mine, owing to the above-mentioned behaviour of the coal, and still much unremunerative work will have to be carried on before the mine will again be in the position of seeing its work ahead for some years. The section of the measures in the shaft and to the dip very closely resembles that in the No. 4 borehole quoted by Mr. Denniston (Geological Reports, 1876–77, p. 137), but the coal is rather thicker and of better quality than that struck in the borehole.

I talked the matter over with Mr. Moody while I was at Kawakawa, and quite concur with his opinion, that the cheapest way now of proving the mine before further opening it up will be by thoroughly boring the company's land; and I further agree with him as to the advisability of putting a borehole down on the "scoria flat," seeing that towards the swamp the coal appears to be more regular and of better quality than elsewhere throughout the mine, and will presumably hold until it thins out against the slates which form the ranges on the other side of the "scoria flat."

The relations of the Waiomio limestones are as vague here as they are in most other places in the North where these beds

occur. They are resting unconformably upon slates, and are not overlaid by any other beds, but, as they resemble in all particulars the Whangarei and Waipu Caves limestones, there is no doubt that they are younger than the coal measures, and presumably are unconformable to them.

MANGANESE MINES.

With regard to manganese deposits, a few miles from Russell there is at present a good deal of manganese showing in both of the mines belonging to the Bay of Islands Manganese Company, but in neither case has there been sufficient work done to guarantee the output for very long. Mr. E. K. Cooper, the manager, informs me that he expects to be able to turn out 5,000 or 6,000 tons of ore during the ensuing year, if he can get rid of it, and I think it quite possible that he may be able to do so, although the patchy nature of the ore makes it very uncertain unless the tutwork is far enough ahead to absolutely show the ore to be got.

At present the ore is simply hand-picked, and of course a considerable amount of waste ensues, which would be obviated were jigging machinery erected, a by no means expensive piece of work.

I understand another lease has been applied for adjoining the land, and some specimens which were handed to me appear good.

I am informed that little or no ore is at present being got from the Waiheke; but I annex a report by Mr. McLaren, Inspector of Mines, on this mine, which he visited lately. He says,—

"The Manganese Mine is situated on the Island of Waiheke, which lies between Coromandel and Auckland. The mine is on the south-east side of a valley about half a mile from the beach, and has been worked from three levels driven in from the hill-side; the third, or present one, being the lowest which can be obtained without sinking.

"The reef, which is very perpendicular, varies in thickness from 2 feet to 16 feet, giving the workings a very irregular appearance; the walls are very hard and good standing rock, and, from their being so perpendicular, have very little collapsing pressure."

In addition to the above, there are deposits of manganese associated with these slates at Whangarei, Waipu, and the Island of Kawau; and, no doubt, should the price of and demand for the ore be sufficient, a large output could readily be secured in the colony.

RELATIONS OF AUCKLAND BEDS.

As directed I have further devoted my attention to the question of what position the Orakei Bay fossiliferous beds actually take in the geological sequence of the colony.

My work this time was chiefly devoted to following the

sequence of the rocks from Auckland to Maraetai, at which point the slates crop up, and beyond which I did not push my investigations.

This section is very distinct in itself, but does not place beyond doubt the relations of the whole sequence. It is shown in the following sketch:—

Section from Maraetai Range to Tamaki Head. *a*. Slates. *b*. Calcareous sandstone. *c*. Clay marls. *d*. Concretionary tufaceous sandstone. *e*. Clay marls. *f*. Concretionary tufaceous sandstone. *g*. Bedded sandstones and clay marls. *h*. Plastic clays and sands. *i*. Recent tufaceous deposits.

Resting unconformably upon the denuded edges of the slates a calcareous sandstone occurs in which are numerous minute forms of fossils; but, so far as I was able to determine, no larger and well-marked forms occur. Amongst the minute forms Dr. Hector has recognized *Gaudryina megastoma* and *Clavulina robusta*, collected by Dr. von Hochstetter from the Whaingaroa clays, which may either represent the Leda marls or grey marls, both of which occur in the Whaingaroa Harbour.

These beds pass up in direct sequence to thin beds of clay marl, with numerous broken remains of plants; and interstratified with them are thick beds of a coarse concretionary tufaceous sandstone, which correspond exactly in character with the concretionary sandstone which I have described as occurring at Tamahua, overlying the Cape Rodney fossiliferous beds.

If mineral character can be in any way relied upon, I should say that these two sets of beds, those at Tamahua, and those at Turanga Creek, and from there to Maungamaungaroa, were the same; but seeing that the relations of these beds is a matter of great importance, as bearing on the extension of our coal measures, it would not be safe to decide the point on those grounds alone, and the fossils cited above would tend to place these beds in a lower horizon.

Resting on this series of concretionary sandstones, &c., come flat-bedded sandstones and clays, which dip a little east of north, and would appear from the contour of their boundary to be unconformable to them. These are the beds which occur at Howick, and are seen along the coast-line from the Tamaki Head to the Maungamaungaroa Creek.

From the Tamaki West Head to Orakei Bay similar beds may be traced undulating generally at very gentle angles until the fossiliferous beds there, which occur as lenticular masses in the clay marls, are met with.

Mr. Cheeseman informed me that another outcrop of the fossiliferous strata had been found between Orakei Bay and Tamaki, but I did not see it myself.

It thus appears that either a direct sequence of strata exists from the calcareous sandstones with minute fossils, which rest upon the slates at Turanga Creek, up to the Orakei Bay fossiliferous strata, with a possible unconformity between the Howick beds and the concretionary sandstone, as previously alluded to, or else that the beds which form the Howick peninsula are unconformably younger than both the concretionary sandstone series and those which are seen between the Tamaki West Head and Orakei Bay. So far as the stratigraphical evidence goes it is, I think, in favour of the former view of the case; but this is by no means conclusive, and as the matter now rests I think all has been done which is possible to settle the point, unless minute mapping of the country, with all the dips and strikes as well as the boundaries, be undertaken, and that still the evidence is of a somewhat unsatisfactory nature.

The character of the country in this district, where the bedding is, generally speaking, at low angles, if we except certain local contortions, and the resemblance which exists between the beds throughout, make the study of the geology one of extreme difficulty, in the event of there being two series of beds with an unconformity between them, as appears probable, and I should be glad to see the matter cleared up in the way I suggest.

I was unable to trace the relations of the Papakura limestones themselves, as they do not occur in the section examined, a belt of slates separating them from the greensand series which I have described, and the plastic clays and sands also intervening.

With regard to the plastic clays and sands, and the volcanic rocks, I have no further observations to add to what has previously been written on the subject, but have shown their approximate boundaries on the map.

TE AROHA GOLD FIELD.

I have, in accordance with instructions, visited Te Aroha, and find that, out of seventy-nine claims which were originally pegged out and registered, only four are at present at work, and two or three protected; that fourteen licensed holdings have been pegged out, none of which are at present at work.

A party have lately offered to take the Prospectors' Claim on tribute, and also the Morning Star, and there appears some probability that the offer will be accepted.

About fifty tons of stone in all have been crushed from the field, the yield varying from 2 dwt. to 7 dwt. per ton, with some richer specimens, possibly bringing the total yield of the field to nearly 50 oz., although I was unable to get reliable returns of this.

The character of the country in which the reefs occur is very similar to that of the Thames. It consists of a greenish-grey pyritous tufaceous rock, but undecomposed, and is traversed by flat-lying reefs, sometimes as much as 5 or 6 feet in thickness,

as at the Prospectors' Claim, which strike about N.N.W. These reefs have a curious brecciated character, and appear to consist of fragments of the country rock cemented or interlaced with thin strings and veins of quartz, which traverse the reef in all directions. These reefs have not, so far, proved to be auriferous, the gold having been found in thin leaders which have a general strike of N. 18° E.; and in this respect another point of resemblance between this and the Thames and Coromandel Gold Fields may be traced, at both of which places the large reefs are non-auriferous, and the gold has been obtained from the small leaders which drop into the reef.

Some reefs, as in the All Nations Claim, have a very large quantity of pyrites associated with them, but have yielded very little gold.

The field does not appear to me to have had a fair trial as yet. It has been clearly demonstrated that the reefs do carry some gold, but, no rich patches having been discovered at the start, it has been abandoned without sufficient work being done to prove the ground, and now it will probably lie idle, as at Waitekauri, until tributers or others find a rich patch, when the attention of the mining community will be again directed to the locality.

Piako District.

As directed, in passing through this district I paid attention to the character of the country and the nature of the soil.

I find that in the Eureka Company's property the land is not cut to any extent by streams, except a few swampy ones between flat rising grounds: the whole area, however, is in process of being drained by artificial means.

The soil is a sandy loam, which varies from a black richly-organic soil to a more chocolate-coloured soil of much the same character.

The subsoil throughout consists of pumice sands, which have at places a good deal of iron in them, and which, as exhibited in cuttings, weather to a deep rusty brown for a considerable depth below the surface.

After passing out of the company's property the character of the land is a good deal changed; it is more undulating, or rather consists of a number of terraces, and streams are far more numerous, some of them having a moderately rapid flow. The subsoil, however, still continues of a light sandy character, and only at a few places did I notice clay at the base of the black soil. After passing Morrinsville the character of the subsoil becomes more clayey, and after heavy rain the whole country is very sloppy, while the district first alluded to was comparatively dry when I rode over it, notwithstanding that heavy rain had fallen for two days previously. The soil throughout appears to be good, but the thickness of it varies from a few inches to a foot, so that, no doubt, the fertile land is very patchy.

ON THE YOUNGER DEPOSITS OF THE WHAREKAURI BASIN AND THE LOWER WAITAKI VALLEY.

REPORT BY ALEXANDER M'KAY.

28th November, 1881.

THIS district was partly examined during the past season, and considerable collections of fossils were made from the younger strata filling the Wharekauri Basin. These, on being examined by Dr. Hector, were found to include teeth and osseous remains of such a remarkable character that I was again instructed to examine the beds whence these had been obtained, for the purpose of determining the exact horizon at which the bones occur, and also for the collection of further specimens. With this object I left Wellington on the 20th June, and was engaged at Wharekauri and in the vicinity of the Macrewhenua River till the 12th August; after which I went to Livingstone, and thence to Oamaru, returning to Wellington on the 20th August.

REPORT.

The additional facts observed during the progress of the present examinations do not materially affect the classification of the younger rocks of the district.

Within the Wharekauri Basin the sequence of the younger rocks to the base of the Cretaceo-Tertiary series is as follows:—

Age.	Formation.
I. and II. Recent to Pliocene	Alluvial and glacier deposits.
IV. Lower Miocene ...	Pareora Formation—
	a. Gravels and sands, with lignite beds.
	b. Marine beds. [Wanting in the Wharekauri Basin.]
V. Upper Eocene ...	——— Formation—
	b. Hutchinson's Quarry beds.
	c. Otakaika limestone.
	d. Kekenodon beds.
VI. Cretaceo-Tertiary ...	Amuri Formation—
	e. Marly greensands.
	f. Island sandstone.
XII. and XIII. ...	Maitai and Te Anau series, forming the basement on which the younger rocks rest.

I., II.—RECENT TO PLIOCENE.

In the previous reports (p. 60, *ante*), already referred to, mention is made of the presence of glacier deposits occurring in the Waitaki Valley near Wharekauri. These were described as seen in that immediate neighbourhood, where they form a high-level terrace, reaching a height of 2,000 feet, on the south side of Wharekauri Creek (Big Gully). The deposit extends north-and-south about two miles, and has an average breadth of about half a mile.

The heavy and angular character of the materials forming this, and the irregular method of its deposition, led me to assign to this deposit a glacier origin. Where it remains undisturbed, as at the high levels mentioned, the materials are all locally derived from the rocks of the neighbouring mountains lying to the westward, and I therefore inferred that those present here were due to a glacier reaching the Waitaki Valley from that direction.*

To the southward of this deposit, and filling the valleys of the larger creeks, or forming terraces up to the 1,000-feet level, are coarse boulder deposits, many of the included blocks in which contain bones and marine shells, which show that the rocks whence these have been derived are of Triassic or Permian age. Not having succeeded in finding these rocks *in sitû* on the Otago side of the Waitaki Valley, and they not being present in the gravels of the present bed of the Waitaki River, I referred to these also as having been brought to their present position by the agency of ice, and inferred that they must have come from the Canterbury side of the Waitaki Valley.

West of the Te Anau rocks forming the hills at the back of the Kurow Station, the valley intervening between these hills and the Kurow Mountains is filled by Tertiary rocks, capped as at Wharekauri by coarse angular drifts, composed, however, of a variety of rocks. These have originally formed a tableland, but are now so denuded as to form a number of ridges rising to 2,000 feet above the sea, which is the height to which the similar deposits at Wharekauri reach. These angular deposits, on being followed southward in the direction of the Kurow River, gradually become more waterworn, and eventually, as well-rounded gravels, seem to merge into or overlie the well-known Kurow gravels, which in my earlier report I have doubtfully referred to the higher part of the Pareora formation. In the valley of the Awakino Creek the younger gravels rest on the older and their associated rocks unconformably, and, unless the Kurow gravels are themselves younger than these, whatever the nature of their junction, there must be unconformity between them and the angular gravels at present under consideration.

It is evident, however, that the high-level angular deposits at Wharekauri are, after an interval of four miles, again represented in the valley of the Awakino Creek, and are there, as at Wharekauri, unconformable to the underlying upper portion of the Pareora formation, carrying seams of lignite or brown coal at its base; and the only question which remains is, whether the Kurow gravels belong to the older or the younger series. If to the younger, we must look upon the gravel deposits at Wharekauri,

* During the second examination of this district Dr. Hector visited the locality, and was of the opinion that these deposits might be referred to the action of the mountain streams piling up these materials as a huge fan, at a time when the Waitaki River had not excavated its valley to its present level.

and in the valley of the Awakino Creek, as but patches of a once widespread formation which filled the whole of the Lower Waitaki Valley, and which, as angular materials in the higher part of the valley, gradually become well-rounded gravels in the lower part and towards the coast-line; and of which important areas yet remain between the Kurow and Otakaika Rivers, and cover considerable tracts on the Maerewhenua tables.

I incline, however, to regard the Kurow gravels as belonging to the lignite series of Wharekauri, and therefore to the higher part of the Pareora formation, although south of the Kurow there appear to be no carbonaceous deposits associated therewith.

IV.—LOWER MIOCENE.

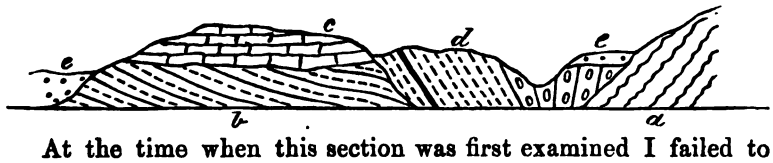
Pareora Formation.—a. *Gravels and Sands, with Lignite.*—These beds have some importance within the Wharekauri Basin, on account of the presence in them of a thick seam of brown coal, which has supplied local wants for a considerable number of years. The beds are at this place highly tilted and obscured by the overlying deposits already described, and, on account of their being in close contact with the lower Cretaceo-Tertiary rocks (VI. *e* and *f*), are liable to be regarded as belonging to that series; and further, on its being shown that this seam does not belong to the true coal rocks of the east coast of New Zealand, viz., VI. *g*, there yet remained the probability of its being referred to the Upper Eocene formation (V.), which in the Wharekauri Basin has for its lowest members a series of light-coloured sands and fireclays very similar to those with which the coals are associated in Formation VI. The mine at Wharekauri is the only locality where coal of this age is known to occur as a workable seam. That this horizon does in many places yield coal is shown by various reports of the Geological Survey Department, lignites of this age being generally found at the base of the Moutere gravels, in the Nelson Provincial District.

On the east coast of the South Island a seam of lignite 2 to 3 feet thick is found in the Trelissick Basin, Canterbury; and another, though of very inferior quality, is found separating the higher and lower parts of the Pareora formation, where these beds are developed near Shrimpton's, White Rock River, South Canterbury.

Within Otago the only locality, other than Wharekauri, where coals of this age are known to occur, is in the district between the Molyneux and the Mataura, where beds of this age occur on the banks of the Pomahaka River. Perhaps also in the Upper Taieri, and at other places in Central Otago, the coals worked may prove to be of this age.

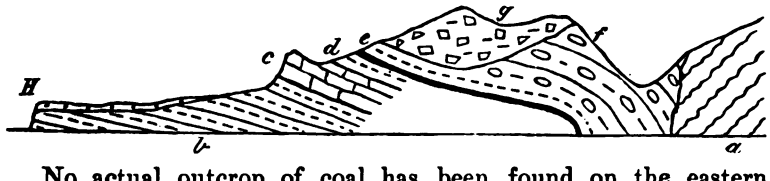
The following section shows clearly the unconformity of the beds *d*, in which occurs the Wharekauri coal-seam, to the beds *b*,

which belong to the lower portions of the Cretaceo-Tertiary series:—



At the time when this section was first examined I failed to observe the exact point of junction between the beds *b* and *d*, which I have since done, and noted that close to their junction with *b* the higher beds stand at a higher angle than shown in the sketch, while the underlying beds are nearly horizontal; and at the point of junction are light-blue marly sands with grains of glauconite, grey quartzose sands being there in contact with them, followed by grey shales with traces of coal and dicotyledonous leaves. It is thus clear that these coal-bearing beds do not belong to the Cretaceo-Tertiary series of which the beds *b* form a part.

The Upper Eocene rocks, which have a large development—at least compared with the other rocks—within the Wharekauri Basin, show at their base a series of grits, sands, and fireclays, which appear likely to carry seams of coal; and, in order to make certain that the actual position of the Wharekauri seam is such as I have placed it in the sequence of formations, it is necessary to show that it does not belong to the Upper Eocene rocks. The following section shows the coal-seam as overlying all the Upper Eocene rocks within the basin:—



No actual outcrop of coal has been found on the eastern side of the hill at *d*, but quartzose grits and grey and rusty-coloured sandstones are there seen overlying the beds *c*, the position of which is clear with reference to all the other beds in the basin. On the northern end of the hill these grits and sandstones are better shown, and rise to a greater elevation than represented in the line of section, and are not there covered by the beds of angular material, *g*. On the eastern and northern sides of the hill the beds associated with the coal-seam are nearly horizontal, or have but a moderate dip to the westward till nearing the abrupt slope descending into Wharekauri Creek, when they suddenly acquire a very high angle of dip, and appear to be dislocated by a fault, as the coal-seam here crops out, and does so in a south direction till covered by the coarse angular gravels which overlie unconformably.

Two miles south of Wharekauri there is an outcrop of coal in

Murray's Creek in which some work has been done, but without showing the presence of a continuous or workable seam. The section here is very confused, and there is a consequent difficulty in determining the precise horizon to which the coal belongs.

The rocks belonging to Formation V. dip at low angles to the N.N.W., and apparently so continue till within a short distance of the old rock forming the high ranges to the westward, when suddenly the coal rocks are met with, standing at high angles, but at the surface so much obscured by slips that no dependence can be placed on observations which may be made at this place.

Further to the south, on the north side of the Big Awakino Creek, coal is being worked which is probably of the same age as the seam at Wharekauri; but, there being no fossiliferous beds in connection therewith, its reference to the Pareora formation rests on the fact that the shales and sands in connection with the coal-seam are followed, as at Wharekauri, by sandstone gravels, which may be traced south across the valley of the creek, and there shown to be identical with the Kurow gravels. These beds, after having been tilted, so as to stand at high angles, were overlaid by the heavy beds of angular materials which have already been described as here forming ridges of hills, reaching an elevation of 2,000 feet above sea-level.

The coal-beds here appear to be arranged as a syncline, outcrops appearing on both the east and west sides of the valley flanking the Kurow Mountains, across which the Awakino Creek makes its way to join the Waitaki River.

A little to the north, within the watershed of the left branch of this creek, there occurs an isolated patch of fossiliferous strata belonging to Formation V., which appears to rest on coal-bearing strata which are seen in the near vicinity, and on the north side of the creek filling the cross-valley, and forming a swampy saddle, which divides this branch of the Big Awakino from the Little Awakino, lying farther to the north. From this saddle patches of ferruginous sandstone and conglomerates occur at frequent intervals in following these in a north-east direction, and appear to be outlying patches belonging to the lower portion of Formation V., which, from the north side of the Little Awakino, is continuous to the Waitaki River, where these lower beds are overlaid by the higher and fossiliferous part of the same formation.

On either bank of the Kurow River these beds are strongly developed as beds of coarse gravel, which are of great thickness. Where these expose sections along their western boundary they are seen to rest on the older rocks without the intervention of the sands and shales which further to the north are associated with the coal-seams. Where the same beds rest on the Otakaika limestone, some distance further down the Waitaki Valley, they show no indications of the presence of coal- or lignite-seams, as is also

the case where the same gravels are strongly developed on the eastern part of the Maerewhenua tables.

V.—Upper Eocene.

b. *Hutchinson's Quarry beds.*—These beds are clearly shown, and are fossiliferous at one point only within the Wharekauri Basin, where a further collection of fossils was made. In the loose grey sands composing the beds at this place a variety of fossils are found; but the locality is chiefly remarkable for the abundance of specimens of *Waldheimia triangulare*, which are sometimes of large size.

The beds cap the Otakaika limestone, V. *c*, of the same formation, and occur in the hill south of Wharekauri Creek, at an elevation of 1,430 feet above the sea.

The higher part of the Maerewhenua limestone must, I now believe, be referred to this formation, to which subject reference will be made further on.

c. *Otakaika Limestone.*—This division of the Upper Eocene rocks is well developed at Wharekauri, and there is richly fossiliferous. It is also present on the north side of the valley of the Otakaika River, where it has long been known as a rock quite distinctive from the Maerewhenua limestone as the latter is seen near the junction of that river with the Waitaki, and hence the distinctive name.

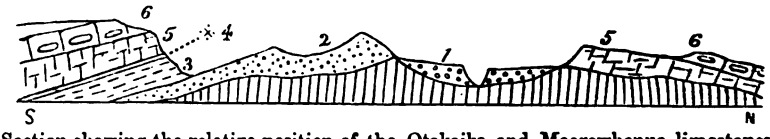
The rock consists of fine-grained calcareous sands, containing a considerable proportion of small foraminifera, thus both in character and position agreeing with the nummulitic limestones of the West Coast and the North Island. Fossil mollusca are abundant in these beds at the Otakaika, at Wharekauri, and on the Canterbury side of the Waitaki Valley at Station Peak, from all of which localities collections have been made.

The middle part of the Maerewhenua limestone belongs, I consider, to this horizon, leaving only the lower portion of that rock as the equivalent of the Ototara limestone.

This is the highest horizon in which remains of *Kekenodon* have been found; for, though bones are found in the Hutchinson's Quarry beds at Oamaru, these usually occur in a fragmentary condition, and as yet no teeth of *Kekenodon* have been found.

In the Wharekauri Basin these beds rest on light- or dark-coloured greensands which constitute the third division of the Upper Eocene rocks, V. *c*, which have at their base a series of sands and clays, and possibly, at places, seams of coal. On the north side of the Otakaika Valley, and at Station Peak on the other side of the Waitaki Valley, this rock rests on the old slates and sandstones of Palæozoic age, and is followed either by Pareora gravels or by beds of doubtful age. Between the Otakaika and Maerewhenua Rivers the same rock forms the middle part of the Maerewhenua limestone, and is overlaid conformably by calca-

reous sands with hard concretions, which represent the Hutchinson's Quarry beds. The Maerewhenua limestone is thus formed by three distinct rocks, the two uppermost of which, though resting conformably on the lower where all are present, yet frequently overlap, so as to rest on the lower beds of the series to which the Maerewhenua limestone belongs, or yet older rocks, and in places on the lower beds of Formation V. to which they are referable.



Section showing the relative position of the Otakaika and Maerewhenua limestones. 1. Old rock. 2. Coal-grits and greensands. 3. Ototara stone, forming the lower portion of the Maerewhenua limestone. 4. Horizon of the *Kekenodon* greensands, which are absent in this section, but occur beneath 5 in the Wharekauri Basin. 5. Otakaika limestone, resting on 1 and 3. 6. Hutchinson's Quarry beds, forming the upper member of the Maerewhenua limestone.

d. *Kekenodon Beds*.—These beds, described (*vide* p. 67) as fossiliferous strata, are present only in the Wharekauri Basin, where their position is that of the rocks next underlying the Otakaika limestone (*vide* p. 68). The fossil shells and corals of these beds were largely collected during my first examination of these beds, and during the second visit attention was more particularly directed to the cetacean remains which occur in the beds. Most of these appear to occur in one horizon, which lies in the middle or upper portion of the *Kekenodon* beds. Portions of five specimens of *Kekenodon onamata* have now been collected from these beds at Wharekauri: of No. 1, the original specimen, teeth, fragments of the skull, tympanic bones, atlas, and fragments of ribs. Close to the above was found specimen No. 18, principally composed of caudal vertebræ.

No. 3, which, on being excavated, proved to be a nearly-entire specimen, 23 feet in length, sustained damage during its carriage to Wellington, so that it is not now possible to put the parts together so as to form an entire skeleton. Most of the more important bones have, however, escaped with but trifling damage.

No. 4 comprised fragments of the skull with tympanic bones, but no teeth, both scapulars, sternum, numerous vertebræ (including atlas and axis), ribs, &c.

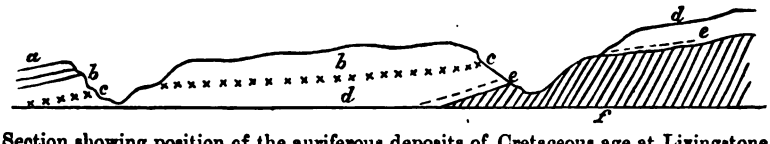
No. 5: Axis, cervical vertebræ, and ribs.

Besides these there was obtained from the Otakaika limestone, or middle part of the Maerewhenua limestone, part of the skull and lower jaws of a young individual, in which are a number of teeth still in position in the jaw, besides several others scattered through the matrix. Cetacean bones are found in the lower part of the Maerewhenua limestone, and in the Cretaceo-Tertiary greensands which underlie, but they differ specifically at least from those which have been noted above.

VI.—Cretaceo-Tertiary.

e. *Marly Greensands:* f. *Island Sandstone.*—Some further collections were made from these beds within the Wharekauri Basin, but no new facts bearing on their stratigraphy were noted. From their outcrop, north of the Maerewhenua River, I traced these beds and the underlying coal-beds, VI. *g*, past Livingstone to the upper part of the Waireka Valley and the Kakanui River.

At Livingstone the quartzose grits forming the beds VI. *g* are auriferous, and yield apparently the whole of the gold obtained in that district. In a former report (Geological Reports, 1876–77, p. 65) I drew attention to this fact, and on the present occasion again visited a number of the claims being worked in these beds. From what I gathered from the miners, it appears that the gold is got in two distinct horizons, namely, in the lower and upper beds of the quartz-grits representing the coal-beds, VI. *g*.



Section showing position of the auriferous deposits of Cretaceous age at Livingstone. *a*. Grey concretionary sands, with fossils. *b*. Greensands, with fish remains. *c*. Upper auriferous gravel cement. *d*. Conglomerate. *e*. Lower auriferous cement. *f*. Schist.

In the lower beds (*e*) the gold is found in patches, and is of a coarser description than that found in the higher beds; and, as a rule, the deposits are richer, but have the drawback of not being so easily found, and often the auriferous wash becomes a hard cement, to extract the gold from which would require crushing machinery.

At the higher horizon (*c*) the gold occurs evenly distributed in a bed of grit, 1 to 2 feet thick, and in this at the present time are being worked the greater number of claims. The upper auriferous band is immediately overlaid by a bed of fossiliferous greensand, in which great numbers of sharks' teeth are found, and this in turn by greyish sands with concretions full of fossils. The whole forms the isolated table-topped hill on which the Township of Livingstone is built.

On the south, west, and north sides of this hill the auriferous bed has been proved, and is at all points being worked with satisfactory results. Where the depth of overlying material is not too great, ground-sluicing and hand-raking is the mode of extracting the gold; but, when the depth of covering renders this method unprofitable, driving is resorted to, and it is this kind of work which shows to best advantage the regular distribution of the metal. On the western scarp of the hill on which the township stands numerous tunnels have been driven to distances beyond

which it is more convenient to leave them, and start others from which for a time the distance of output will be less.

The average earnings of the miners engaged in driving is about £2 per week per man, those engaged in the sluicing claims making from £5 to £10, the highest returns being obtained on the northern bank of the Maerewhenua River, where some rich auriferous ground is leased from the Hon. Robert Campbell.

The dip of the strata and the slope of the surface of the country being in the same direction, and the latter being deeply cut into by gullies, gives a great length of exposure to the upper auriferous bed, so that it is easily prospected over an area of ten or twelve square miles. The lower beds cover a considerable extent of the hill-slopes looking east, which lie to the south-west of Livingstone, between the Awamoko Creek and the Kakanui River.

Altogether, with a more abundant water supply, and a larger population, it does not appear to be a doubtful matter that a prosperous future is in store for this as a gold-mining district.

THE COAL-BEARING DEPOSITS NEAR SHAKESPEARE BAY, PICTON.

REPORT BY ALEXANDER M'KAY.

HAVING been instructed to examine the lately-discovered seam of coal situated on the east side of Shakespeare Bay, near Picton, and at the same time to make an approximate determination of the extent of the coal-bearing area at that place, I have the honor to report that, in compliance with such instructions, I proceeded to Picton on the 15th of August last.

For several days I was employed in the vicinity of Shakespeare Bay, and in examining small outliers of Cretaceo-Tertiary rocks in the neighbourhood of Picton, after which I went to the Grove, at the head of Queen Charlotte Sound, where coal-rocks were also supposed to be present. On returning from the Grove I spent two days in the district south-east of Blenheim, and thence returned to Wellington on the 26th August.

REPORT.

Since last I had occasion to report on the coal discoveries at Shakespeare Bay vigorous prospecting has been carried on up to the present date, the results being that coal outcrops have been found at three different places, one of these being of considerable importance.

Last year I sketched the boundaries of the coal-bearing rocks, and indicated the lines along which I thought it probable coal-seams might be found; but at the same time, judging from the small area covered by the coal-rocks, and their highly-disturbed

condition, I did not take a very hopeful view of its future as a coal field. Since then an important discovery has been made on the east side of the valley, and close to the head of Shakespeare Bay, a seam of coal at least 13 ft. 6 in. in thickness, and of very superior quality, being there exposed.

Here I commenced work by examining the seam as far as it has yet been opened by crosscuts or drives, and, by a close examination of the immediate locality, sought to determine what were the probabilities of its being found at other points in the same line of strike.

The seam occurs close to the boundary of the coal-bearing area, and is, at right angles to its strike, about three chains beyond high-water mark. In the direction of its strike towards the north the distance to the water's edge is about 5 chains, while, to the south, slope and alluvial deposits prevent the exact determination of the limits of the coal-beds: there is, however, reason to suppose that they continue in this direction some 5 to 7 chains.

The coal is found quite at the surface, and was laid bare by accident, and, as now exposed, shows a seam about 6 feet in thickness, which strikes north-and-south, and dips at high angles to the eastward. After laying it bare along the strike for about 15 feet an open-cast cut was put through the seam, which rapidly thickened as lower levels were reached. On the seam being cut through, a shaft was sunk alongside its western face, proving coal from the outcrop to a depth of 25 feet. At this level the seam was again driven through, and proved to be 13 ft. 6 in. in thickness. This lower level being only 4 or 5 feet above tide-mark, an adit was driven to the nearest point in a north-west direction, and some further attempts were made to prove coal at yet lower levels.

Mr. Renfrew, manager for Mr. Fell, the lessee, informed me that by boring he had proved coal to exist to a depth of 30 feet below the level of the drive, or for 55 feet from the outcrop. While the lower level was being driven coal was met with on the north side of the drive 15 to 20 feet west of the line of strike as indicated at the surface. Putting in a side drive, this was followed to the northward some 10 feet; but, not presenting the appearance of a defined seam, the drive was discontinued, although heavy masses of coal are present, which, I think, are continuous with the principal body of coal sunk upon. At the level of the upper crosscut the coal has been followed to the north; first by removing the shales on its western side and leaving the coal standing, and, finally, by driving when the depth of material to be removed became inconveniently great. In this way the seam has been proved along its strike for 35 feet. The explorations to the northward show that the coal thins in that direction, and, at the farthest point reached, is absent in the level driven; nor has it been proved at this point on the surface, although showing overhead in the drive.

At the main opening the strike indicates that the coal-seam should reach the shore-line at a distance of about 5 chains in a northerly direction, and close to the point where it should have reached the beach a narrow exposure of Permian (?) sandstone shows in the low cliffs bounding the shore-line.

From this point to the beach near the mouth of the drive, with the exception of the first 20 feet, a continuous section of the coal-rocks is exposed along the shore-line; but nowhere can the coal itself be detected.

The coal-rocks here dip westerly, away from the Permian rocks on which they rest. The lowest bed is a rubbly breccia, apparently the crushed surface of the Permian rock, and this is followed by a grey sandstone clearly belonging to the younger series; but not more than 3 feet or 4 feet of this rock is seen, a slip obliterating the section here for a short distance.

At about 25 feet from the base of the section dark-coloured sandy shales, dipping west at angles of from 45° to 50°, show on the west side of the obscured part of the section, and here about 3 feet of shell-limestone is seen on the beach, conforming to the general strike, and dipping to the west at high angles. The dark shales yield carbonized plant-remains, and a few marine shells, fish-scales, &c. Following the limestones, and in a drive now being put in at this point, soft grey sandstones succeed, the strike and dip of which are very difficult to make out; but as this or a very similar rock is passed through in the drive, and lies on the west side of the coal, it must be looked upon as the highest of the sequence here seen.

Forty or fifty feet along the beach from the base of the coal-bearing series a drive is at present being driven in a south-east direction, which must reach the old rock at less than 40 feet, and thus set at rest the question whether or not the coal is present thus far to the northward in the line of strike of the seam first laid bare at the surface.

Should this drive fail to cut the coal-seam it must be presumed that, in the drive reaching the main body of the coal, the irregular masses of coal seen on the north side of the drive indicate that the strike of the seam has changed to a north-west course, or, if preserving a north-and-south course, it has been faulted to the westward. This latter assumption is, perhaps, the more probable, for, as has been said, at the northern end of the tunnel put in along the face the coal is cut off, and that which is seen on the west side of the drive appears to be continuous with that in the lower drive.

As yet no attempt has been made to follow the coal towards the south, so that what may happen is a matter of pure speculation, further than that it cannot be considered probable that the coal extends more than 7 chains in this direction, unless, indeed, it be proved that a narrow strip of the coal-bearing series extends

st side of the swampy valley which flanks the older

ocks being seen at the surface, I have given it the benefit doubt, and coloured this part of the area as possibly having al-rocks underlying the alluvial and slope deposits which are seen on the surface.

I have spoken of the latest discovery first, as being the most important, and that which I was specially sent to examine. The other places at which coal has been found since my visit last year are situated on the west side of the valley stretching south from the head of Shakespeare Bay. The coal first found on this side of the valley is described in my last year's report, and crops out in the bed of the most northerly branch of Laymont's Creek, as shown on the map accompanying this report.

From this point northward to the beach on the west side of the bay no coal has yet been found. At the point marked "Borehole," and just within the rocks of the coal area, borings were made to a considerable depth, over 200 feet, and limestone and traces of coal were found; but the indications did not warrant sinking a shaft to the very considerable depth at which these were met with. This borehole proved the presence of rocks which, on the east side of the bay, have been regarded as strong indications of coal; therefore, in spite of an apparent north-easterly strike of the rocks near the coal in the first branch of Laymont's Creek, it seemed probable that the coal would continue south nearly in the same line as between this place and the borehole on the beach. Acting according to this surmise a prospecting drive was put in on the north bank of the second branch of Laymont's Creek, and coal, covered only by surface-drift, now shows in the end of the drive; but, as yet, it has not been proved to be *in situ*, the work having been stopped as soon as the coal was reached, and without cutting any of the associated coal measures.

What is seen is probably the outcrop of the seam, as a few yards to the south, on the other bank of the creek, a shaft has been sunk, passing through coal dipping at high angles to the eastward. This shaft, when I visited it, was partly filled with water, and could not be closely examined; but it was apparent that the seam here was striking more to the south-east than elsewhere on this, the west, side of the valley.

Farther to the south, beyond the third branch of Laymont's Creek, a tunnel has been driven south-west and westward into the hill between this point and the fourth branch, and, as far as driven, this passed through greensands, and, not showing coal where it was expected to be cut, was abandoned. From the strike of the seam, as seen at the nearest point to the northward, I should say that the coal lay to the eastward of the point where this drive was commenced, although from the dip of the strata it might fairly be

inferred that it lay to the west in a line with the outcrop showing in the fourth or next branch of Laymont's Creek.

In the fourth branch of Laymont's Creek the coal shows at a height of 325 feet above the sea, and at this point strikes N. 15° E., with a high dip to the westward, and on that side is in immediate contact with schistose or highly-altered rocks. The total thickness of the seam is 8 to 9 feet; but shaly bands are interstratified with it, materially lessening the thickness of coal.

At this point the coal-rocks are but a narrow belt involved among the older rocks, having the Permian sandstones to the east and the schistose rocks to the west. To the south-west they are continued along the face of the range, rising to a height of 600 feet above the sea, where fossiliferous sandstones are found resting on the schistose rock, and there show a high dip to the east.

In the head of the creek falling into Picton Bay, at the cemetery, considerable masses of limestone are found, and a little higher up the creek a thin seam of coal, overlaid by sandstone, is said to occur. This line continued would pass abreast of the elevation somewhat to the westward of the railway-line, where coal is reported to occur.

At Pugh's old shaft on the east shore of Shakespeare Bay, where indications of coal were first found, work has been discontinued, and since my last visit prospecting works have been carried on under Mr. Pugh's direction along the northern boundary of the coal-bearing strata, tunnels being driven both from the Shakespeare Bay and Picton sides of the narrow neck of land. That tunnel on the Shakespeare Bay side has been put in a distance of fully 200 feet, and coal followed for the latter half of that distance. The coal is found close to the junction, and often in contact with the schistose rocks lying to the north. There is no defined seam or considerable body of coal, although in prosecuting this work a few tons of coal have been obtained. As seen in the drive the coal occurs in the most irregular manner, thinning down to a few inches, or swelling to 2 or 3 feet in thickness; now in a horizontal position, and a few yards off standing vertical, or having a high dip, and apparently passing under the schistose rock. Evidently here the rocks are much disturbed by faulting, and apparently the original disturbance has been aggravated by landslips from the hill to the northward. Further work here may be the means of reaching such a body of coal as will pay for working; but none such as yet shows in the works as far as they have been prosecuted.

On the Picton side of the narrow neck of land a tunnel was driven some years ago at a point where indications of coal were found on the western shore of Picton Bay. During the past year this has been further driven to a distance of fully 100 feet, but without obtaining results of an encouraging character, and in the meantime work is at a standstill. Here, as on the west side of the

neck of land, the dip of the strata is to the N.N.E., and the tunnel is driven just within the coal-bearing area. The rocks passed through are dark sandy marly shales containing carbonized plant-remains, and here and there a thin streak of coal. These shaly beds rest on sandstones and conglomerates, the parting between which has been followed in driving the tunnel.

During the past year some prospecting for coal was carried on at the elevation, one and a half miles south-west of Picton, where indurated marls of Cretaceo-Tertiary age are present; but not being successful this work is now discontinued. The place selected is not, in my estimation, the most favourable, being situated at the northern corner of the outlier, where a very narrow exposure of the younger strata is preserved, being included between older rocks.

On the height of land, and on the south side of the saddle, the exposure of younger rocks widens to from 250 to 300 yards, and on the eastern side of this area the rocks can be so far examined that their general character is determinable. As far as made out they consist wholly of marly strata, containing concretionary masses of a soft grey cement-stone. The dip is obscure, but appears to be to the westward. I examined the junction made between these and the older rocks to the eastward, hoping to discover on this line the grits and sandstones associated with the coal at Shakespeare Bay, but found that the marls rested on the older rocks at all points where a junction could be found between the two series.

Along the western border of this outlier the junction is obscured by recent shingle and slope deposits, and, though shales with indications of coal are reported to show in one of the creeks on this side, I have not been able to find the exact locality.

North-east of the elevation, between there and the Town of Picton, a small patch of Cretaceo-Tertiary marls is exposed in the cuttings of the railway-line, and since last year another patch has been found in the bed of the Waitohi Stream within the town itself. Of this latter discovery the exposure is but a narrow ledge of gritty marls crossing the bed of the stream, bearing about north-and-south and standing nearly vertical, the dip being very high to the east. This rock is followed at a few yards' distance by a similar ledge of marly rock, identical with the rocks of this age seen at the elevation.

Regarding these as rocks connected with and overlying the coal-seam, the gritty greensand rock being seen in such relationship at Shakespeare Bay, there is a possibility of a seam of coal lying more to the west, between the creek and the main street passing through Nelson Square.

Except within the watershed draining into Shakespeare Bay no decided indications of workable seams have been found, and in what I have yet to say I shall confine myself to a description of

this area, and, as far as known facts will permit, endeavour to indicate the points at which coal may yet be looked for.

The accompanying map shows moderately accurately the extent and outline of the coal-bearing area. On the west side of Picton Bay rocks belonging to the coal-bearing series begin at a point directly north-west of Picton Wharf, where conglomerate, sandstones, and limestones form a sharp syncline and strike in a north-western direction. At this point the hills slope abruptly to the water's edge, and the boundary of the highly-inclined coal strata follows a nearly west line till crossing the bridle-road at a height of about 150 feet above the shore-line. Near the crest of the ridge, between the base of the section on the Picton Bay side and Shakespeare Bay, the strata on the south side of the syncline dip at a much lower angle, and the lower beds stretch along the ridge for a distance of 10 or 12 chains, and attain to a height of 275 feet above the sea, or within 50 feet of the highest point of the ridge between Picton Bay and the upper end of Shakespeare Bay. Deep soil, fern, and scrub are obstacles in the way of ascertaining the exact nature of the rocks along this part of the boundary-line, except from the crest of the ridge following the sinuous line which the boundary follows to the water's edge on the east side of Shakespeare Bay.

On the western slope, near the top of the ridge, conglomerates are met with as the lowest bed of the younger series, and these, containing a considerable percentage of lime as a cementing medium, form hard rocks, exposed here and there above the general surface of the hill-slope. Succeeding these are fine-grained sandstones, weathering into rounded masses, which in grain and character closely resemble the spherical boulders of the Amuri and Waipara sections; they, however, contain no fossils, except fragments of plants too obscure to be identified.

The dip of the beds is here to the north, and apparently at an angle little greater than the slope of the hill in that direction, as higher rocks are not seen until reaching levels less than 100 feet above the sea, or until we follow the beds north as far as the deeper part of the syncline, already mentioned, which should reach Shakespeare Bay near or a little north of the first prospecting shaft sunk on the east side of the bay.

The southern boundary of that part of the field as yet described, trending north-west from the crest of the ridge to the shore of Shakespeare Bay, separates the entire field into two distinct areas; but on the shore-line the exposure of old rock is so narrow that it is almost certain, half a chain from the shore, the rocks of the two areas are continuous below the water-line.

Following the shore-line from this place northward, soft grey sandstones are first met with, followed by dirty greensands, pebble-beds, and marly shales, with traces of coal. At the point marked "Pugh's shaft," where coal was first found, the rock again

changes to grey and rusty-coloured sandstones, which are thence found along the shore-line to the bottom of the indentation lying to the northward. Beyond this the rocks are not so clearly exposed, but there is evidence that they become of a more shaly character when followed to the north, and that in section these rocks are inverted near their junction with the schistose rocks. The shore-line of this part of Shakespeare Bay, it will thus be seen, gives evidence of the presence of an anticline in the middle part, with a syncline both to the north and south, that on the northern side being overturned. The anticline is raised at the eastern end, and near the shore plunges rapidly towards the bay, so that in section the lowest beds are not seen, and the rocks for a short distance strike N.N.E., dipping at high angles to the westward. At the southern end the lowest rocks seen are sandstones, and these, appearing a little to the northward of Pugh's shaft, show that, whether by a fault or the folding of the strata they are thus brought to the surface, the sequence is repeated in the northern end of the section.

The northern boundary of this part of the field is so obscured by slope material and slips from the hill to the north that until reaching the water's edge in Picton no rocks can be seen. Along the shore of Picton Bay the section consists of a central anticline, showing old rocks at the water's edge, overlaid, a few feet above the water-line, by the younger rocks, which to the south form a deep narrow syncline, but to the north dip at moderate angles on the south side of the syncline, and on the north side are probably inverted, as on the Shakespeare Bay side of the peninsula, but here are so obscured that what their position is cannot be exactly made out.

From the drive on the east side of the neck of land, southwards along the shore of Picton Bay, the section is as represented below. From its southern end to the point marked "tunnel" the rocks in this section are clearly exposed, and show no sign of the presence of coal, and, as far as I may judge, the only chance of its presence lies close to the schist at the northern end of the section. What, at this point, are the probabilities of a workable seam of coal being present may be judged from the prospects seen in the tunnel driven from the Shakespeare Bay side in approximately the same beds and under like conditions.

Whatever may be the ultimate results of prospecting operations in this part of the area covered by coal-bearing rocks, these as yet have not been of a satisfactory character, and while, as in the southern part of the field, workable coal may be found, it is very difficult to say at what point this should be sought for. To me it seems clear that along the northern boundary the strata are too much disturbed to enable a thin irregular seam of coal to be worked with profit. It is true that the seam may by increase of thickness obviate the first difficulty; but in the end of the present

drive the prospects are no better than those much nearer its mouth. At Pugh's old shaft on Shakespeare Bay the strata proved much contorted, and, though the work was carried on in the lower beds of the series, coal was not found in any but very small quantities.

At points where the strata dip at lesser angles, as for instance the slope of the ridge to the south-east, or along the shore of the bay a little to the N.N.E., further trials might be made; but until the more promising finds in the south-western part of the field have been proved to be more extensive than yet shown, I should be inclined to discourage prospecting in this part of the field, unless it were found possible to work without great loss the better parts of the coal met with in the drive at the north-west corner, and which might possibly lead to something.

The boundary of the west and southern part of the field trends a little to the west of south from the eastern shore of Shakespeare Bay for a distance of about 5 chains, at which point the large seam of coal is being opened out; but further to the south the continuance of the coal strata cannot be proved, as the surface is deeply covered with alluvial and slope deposits. It is, however, more than probable that the coal strata extend in this direction for some 5 or 6 chains, and presumably the coal-seam will be found thus far. At this point it becomes a matter of opinion whether the coal-rocks are continuous along the east bank of Williams's Creek, or turn sharply to the south-west and west, as shown in the map accompanying this report, till on the lower slopes of the ridge between Williams's and Laymont's Creeks the boundary again turns to the south. Beyond this for some distance to the south-west the boundary cannot be clearly traced, nor can it be even approximately determined until the south side of the spur between the third and fourth branches of Laymont's Creek is reached, whence it may be traced through bush-covered country to its southern termination.

Along the western boundary the actual junction of the coal-bearing strata with the schistose rocks is but seldom seen; but it is quite apparent that the coal outcrops, with one exception (that farthest to the south), lie a little way east of this boundary, and apparently at a greater distance from it than does the outcrop of the thick seam on the east side of Shakespeare Bay.

Along the western line of outcrop there are, as has been proved, a number of coal outcrops; but it is still problematical whether or not these are continuous one with the other, thus forming an unbroken seam. Further, as no work has been done which proves that these outcrops are regular in thickness, or extend more than a yard or two beyond the shafts or tunnels sunk or driven to intersect them, it is manifestly a difficult matter—I should say a matter of pure guess—to estimate the amount which may be won rom this part of the field.

From the large seam being opened on the east side of the bay it is certain that a few thousand tons of coal can be profitably extracted; and supposing, as seems probable, that the seam maintains an average thickness of 10 feet for 5 chains south of the point where it is cut, then, by working it to no greater depth than has yet been proved, viz., 60 feet below the surface, a block of coal equal to about 9,000 cubic yards would be available for working.

ON THE CASWELL SOUND MARBLE.

REPORT BY MR. ALEXANDER M'KAY.

14th November, 1881.

During the three days that the "Kennedy" remained in Caswell Sound, from the 30th October to the 3rd November, the weather was so stormy and wet that only the most urgent examinations could be undertaken. Anchor was first dropped on the north shore of the sound, nearly opposite Dog Point, where a slight indentation having a stony beach, backed by a few acres of flat ground, is bounded by rocky bluffs on either hand. During the afternoon the steamer was shifted to the south side of the sound, so that the two hours she remained here was the only chance I had of examining the rocks on the northern side.

The rocks forming the western headland of the little bay are of a granitic character. At the eastern end of the stony beach a wooded ridge about 100 feet in height slopes abruptly to the water's edge, and, striking north, abuts against and loses itself in a line of high cliffs which, starting from a point higher up the sound, strikes north-west and west, forming a semicircular wall of rock at the back of the bay and the flat ground already mentioned. The ridge forming the eastern headland of the little bay is composed of blue or grey marble, showing from the water's edge to its highest point, and from the point where this ridge joins the line of high cliffs the marble is continued to the north-west. The total thickness of the outcrop of calcareous rock may be estimated at 200 feet. The marble rock is sound and free from joints, and apparently could be quarried in blocks of any size required. Lines of stratification are to be detected, showing that the dip is to the south-east and east; and at many places the marble contains masses of granitic rock of varying sizes, while at other places scales of mica and graphite and nests of crystals of iron pyrites occur in the lines of bedding, or are promiscuously scattered through the body of the marble rock itself. Much of the stone is, however, comparatively free from these impurities, and for those purposes for which it is suitable might be worked at a moderate cost. So far as I examined it I found that the marble was evenly bedded, and lacked the highly-contorted structure of a

blue marble said to occur on the same side of the sound, about two miles inside the heads, but which I had no opportunity of examining, and of which the exact locality had not been discovered when the steamer left.

The white statuary marble, towards the development of which the chief energies of the company are directed, shows at the water's edge on the south side of the sound, about one mile west of Dog Point. The total thickness of the deposit at this point is from 45 to 50 feet. The stratum strikes from the shore of the sound in a south-east direction, and dips to the south-west at an angle of about 45°, in which direction the calcareous rocks are overlaid by a dark-grey granitic rock, from which veins varying from 6 to 18 inches are projected in an irregular manner into the upper portion of the marble. These veins and other isolated enclosures of similar rock somewhat mar the look of this part of the quarry; but, as far as external appearances go, this upper portion will yield larger blocks of stone than the central part of the quarry. Several blocks derived from this upper part of the deposit lie near the water's edge at the foot of the steep slope formed by the marble outcrop. These might measure 3 ft. x 2 ft. x 2 ft., and considerably larger blocks could be obtained *in situ*, but only by the production of a considerable amount of smaller blocks and rubbly material. The marble in this upper portion of the quarry may be from 8 to 10 feet in thickness.

The middle portion of the quarry, some 20 to 25 feet in thickness, presents externally a very shattered appearance, and the bands of stone in it are undoubtedly much jointed. I believe, however, that on the removal of the surface stone many of the joints and fissures will disappear, as clearly a great number of these are due to accidental fractures rendered more evident by the powerfully solvent waters escaping from the forest-covered slopes at a higher level. In the lower portion of the quarry there is a thickness of from 10 to 12 feet of a sounder description of stone, from which the largest blocks and perhaps the finest description of marble will be obtained. Near the base of the deposit the stone is of a bluish tinge, and includes fragments of granitic rock, and from its position cannot be so conveniently worked as the upper and middle portions, unless, indeed, the whole body of stone be removed.

Along the junction of the marble with the underlying granitic rocks a nearly circular recess bounded by vertical rocky walls recedes from the shore-line a distance of about 20 feet. The bottom of this is filled with blocks of marble and other rocks from the cliffs overhead. In the face of this cliff is the entrance to a cave which has a single gallery, 8 to 10 feet wide and 12 to 14 feet high, running along the strike of the marble stratum, or in a south-east direction, for a distance of 200 feet. In the pile of *débris* lying in front, and partly choking the entrance to the cave, are

several blocks of marble, the largest of which is about 5 feet in length, 3 feet 6 inches in breadth, and from 2 feet to 2 feet 6 inches in thickness. From one of the smaller of these blocks was obtained a specimen 18 in. x 14 in. x 7 in., which I brought with me. At its entrance the cave lies within the marble deposit; but some 40 feet from the entrance the underlying granitic rocks appear in the north-eastern wall. Farther on these shortly disappear, and for the remainder of the distance the cave lies wholly within the marble itself. Inside the cave much of the stone overhead and in the higher part of the cave-walls has a shattered appearance; but underfoot, where smoothed by the action of the underground stream which at several places still flows along the bottom of the cave, the marble looks sound, and apparently could be raised in blocks of considerable size.

Along the south-western wall of the cave enclosures of non-calcareous rocks were observed, which, as in its upper part, are likely to be troublesome in working the quarry.

At the surface the marble can be traced no farther than the brow of the cliff, in which it is seen at the water's edge, and it is therefore in the cave that its extension in a south-east direction is ascertained, although such a direction was indicated by the strike of its junction with both the underlying and overlying rocks.

On the higher part of the range to the south-east, and lying in the line of the marble outcrop should it extend so far, are lofty cliffs of light-coloured rock which may possibly be marble, the exact nature of which the boisterous weather prevented my ascertaining. I could only endeavour to judge of this by examining the materials brought down from the same line by a mountain stream falling into the sound a quarter of a mile above the quarry, but found nothing but an occasional block of highly-contorted blue marble; nevertheless I doubt not but that the white marble will be traced for a considerable distance south-east in the direction of its strike, as observed at its exposure on the shore of the sound and in the cave excavated along its course in that direction.

In the foregoing report I have given the facts observed as favourable a colouring as in my opinion they will bear. Having no experience in the working of such deposits as those forming the subject of this report, my opinion as an expert can apply only to the geological conditions under which the marble occurs, and, therefore, with reference to the more special subject, namely, the prospects of the deposit being worked profitably as a marble quarry, I have only described things as seen at the surface, or drawn such inferences as were fairly deducible from the facts themselves; and, beyond what is already stated, I do not consider it to be within my province to indicate what in the future the company's prospects may be: yet I would here state that, in working the white quarry, there can be no doubt but that a large amount of rubble and small blocks will be produced, and it is also

certain that the larger blocks are liable to contain coloured patches and enclosures of non-calcareous rocks of varying size, so that much care will have to be exercised in trying to avoid these defects. Nevertheless there is every prospect that marketable blocks will be produced in quality equal to the sample specimen; but until the quarry is fairly opened out the average size and frequency in which these will be found is but a matter of speculation.

APPENDIX.

INDEX TO FOSSILIFEROUS LOCALITIES IN NEW ZEALAND.

THE following is a list of the numbers which distinguish the fossils from each locality in the Colonial Museum, and by which they are referred to in the Geological Reports, together with the formation in which the locality is placed according to the classification at present adopted in the work of the Geological Survey.

The year in which each collection was made is also given, to assist reference to the reports in which the localities are described, and the name of the collector is indicated as follows: H., Hector; Ha., Von Haast; Ht., Hutton; Cr., Crawford; C., Cox; M., McKay; B., Buchanan; and a few others mentioned by name.

There are in addition many fossiliferous localities the collections from which, having been made during the provincial surveys of Canterbury, by Von Haast, and Otago, by Hector, are preserved in the Christchurch and Dunedin Museums, and are not included in this list.

JAMES HECTOR,
Director.

7th June, 1881.

TABLE OF FOSSILIFEROUS FORMATIONS IN NEW ZEALAND.

I. Recent—
- *a.* Moa beds.
- *b.* Alluvia.
- *c.* Volcanic.
- *d.* Shingle plains.

II. Pliocene—
- *a.* Shingle plains.
- *b.* Pumice sands.
- *c.* Lignite beds.
- *d.* Kereru beds.

III. Upper Miocene—
- *a.* Wanganui beds.
- *b.* Awatere beds.

IV. Lower Miocene—
- *a.* Ross beds.
- *b.* Mangapakeha beds.
- *c.* Pareora beds.

V. Upper Eocene—
- *a.* Mount Brown beds.
- *b.* Oamaru beds.
- *c.* Nummulitic beds.

VI. Cretaceo-Tertiary—
- *a.* Grey marls.
- *b.* Ototara stone.
- *c.* Fucoidal greensand.
- *d.* Amuri limestone.

VI. Cretaceo-Tertiary—*continued.*
- *e.* Island sandstone.
- *f.* COAL FORMATION OF NEW ZEALAND.
- *g.* Black grit.
- *i.* Conglomerate.
- *k.* Propylite breccias.

VII. Neocomian—
- *a.* Conglomerates with coal.
- *b.* Porphyries.
- *c.* Greensands.

VIII. Jurassic—
- U. Upper—
  - *a.* Mataura beds.
  - *b.* Coal seams.
- M. Middle—
  - Putataka beds.
- L. Lower—
  - Flag Hill beds.

IX. Liassic—
- *a.* Catlin's River beds.
- *b.* Bastion beds.

X. Rhœtic and Triassic—
- *a.* Otapiri beds.
- *b.* Wairoa beds.

XI. Permian—
- U. Upper—
  - *a.* Oreti beds.
  - *b.* Great conglomerate.
  - *c.* Great sandstones.
- L. Lower—
  - *a.* Mount Potts beds.
  - *b.* Kaihiku beds.
  - *c.* Glossopteris beds.
  - *d.* Conglomerates.
  - *e.* Red sandstones.

[*Upper Carboniferous not yet identified.*]

XII. Lower Carboniferous—
- *a.* Maitai slates.
- *b.* Te Anau beds.

XIII. Lower Devonian—
- Reefton beds.

XIV. Upper Silurian—
- *a.* Baton River slates.
- *b.* Limestones.
- *c.* Serpentinous slates.

XV. Lower Silurian—
- *a.* Graptolite slates.
- *b.* Marbles.
- *c.* Hornblende rocks.

	Locality.	Formation.
1.	Fern beds, Kais Hill, Amuri Bluff, M., 1876	VIII*a.*
2.	Calcareous conglomerate, East Wing, Amuri Bluff, M., 1876 ...	VII.
3.	Belemnite bed, East Wing, Amuri Bluff, M., 1876	VII.
4.	Trigonia beds, East Wing, Amuri Bluff, M., 1876	VII.
5.	Nummulite beds, Whareama, H., 1867	V*c.*
6.	Aporrhais beds, East Wing, Amuri Bluff, M., 1876	VII.
7.	Greensands, below black grit, East Wing, Amuri Bluff, M., 1876	VII.
8.	Black grit, East Wing, Amuri Bluff, M., 1876	VI*g.*
9.	Boulder sands, East Wing, Amuri Bluff, M., 1876	VI*f.*
10.	Concretionary greensand, East Wing, Amuri Bluff, M., 1876 ...	VI*e.*
11.	Teredo limestone, East Wing, Amuri Bluff, M., 1876	VI*e.*
12.	Amuri limestone, Amuri Bluff, M., 1876	VI*d.*
13.	Amuri group, West Wing, Amuri Bluff, M., 1876	VII.
14.	Oaro Creek, Amuri Bluff, M., 1876	VI*e,f.*
15.	Old Diggings (Hughie's), Buller River, Nelson, H., 1873; M., 1874	VIII*a.*
16.	Lower Kaihiku Gorge, Otago (plants), M., 1873	XI*a.*
17.	Lower gorge of Purerua River, Otago, M., 1873	XI*a.*
18.	Lower gorge of Purerua River, Otago, M., 1873	XI*a.*
19.	Old Mill, Owake Creek, Catlin's River, Otago, M., 1873 ...	IX*a.*
20.	Mouth of Catlin's River, Otago, M., 1873	IX*a.*
21.	Pholadomya Point, Catlin's River, Otago, H., 1865	IX*a.*
22.	Greensands, Green Island, Otago, H., 1865; M., 1873 ...	VI*e.*
23.	Selwyn River, Canterbury, Ha., 1871	VI*e,f.*
24.	Amuri Bluff, B., 1867	VII.
25.	Amuri Bluff, Ha., 1869	VI., VII.
26.	Callaghan's Hill, Westland, H., 1866	III*d.*
27.	Ten-Mile Creek, north of Cobden, Nelson, M., 1874	VI*f.*
28.	Welshman's Terrace, Brighton, west coast of Nelson, M., 1874 ...	VI*f.*

	Locality.	Formation.
29.	Brunner Mine, Grey River, Westland, H., 1870; M., 1873 ...	VI*f.*, *g.*
30.	Morley Creek, Southland (Unio beds), H., 1869	VI*g.*
31.	Island sandstone, Woodpecker Bay, Brighton, west coast of Nelson, M., 1874	VI*f.*
32.	Nine-Mile Bluff, Cobden, west coast of Nelson, H., 1866; M., 1873	VI*f.*
33.	Above Island sandstone, Woodpecker Bay, Brighton, west coast of Nelson, M., 1874	VI*e.*
34.	Inland of White Rock Point, Mokihinui River, Nelson, M., 1874	VI*e.*
35.	Cobden limestone, Greymouth, Westland, H., 1866	VI*d.*
36.	Conway River, Marlborough, Ha., 1869	VI*d.*
37.	Castlepoint, east coast of Wellington, H., 1867	III*b.*
38.	Rainy Creek, Reefton, M., 1874	VI*f.*
39.	Whangape Lake, Auckland, Ht., 1867	VI*d.*
40.	Tokomairiro limestone, Waihola Gorge, Otago, B., 1869; M. 1873	VI*b.*
41.	Black limestone, Tokomairiro, Otago, H., 1865	VI*e.*
42.	Batten River, Nelson (quartz grit), H., 1867	VI*f.*
43.	Raglan, west coast of Auckland, H., 1866	VI.
44.	Mokihinui River, Nelson, M., 1874	IV*b.*
45.	St. Kilda, Brighton, west coast of Nelson, M., 1874	VI*f.*
46.	Seal Rock, Brighton, west coast of Nelson, H., 1870	VI*b.*
47.	The Castles, Slate River, Nelson, C., 1881	V*a*, *b.*
48.	Inangahua Junction, Buller River, Nelson, H., 1873; M., 1874...	VI*f.*
49.	Inangahua Ferry, Reefton and Westport Road, Nelson, H., 1873; M., 1874	VI*e.*
50.	Christie's, Inangahua, Nelson, H. and M., 1874	VI*e.*
51.	Aotea, west coast of Auckland, H., 1866	VI*d.*
52.	White Cliffs, Taranaki, H., 1865 and 1878	VI*a.*
53.	Caversham, Dunedin, Otago, H., 1869	VI*a.*
54.	Cape Turnagain, south coast of Napier, M., 1875	II*a.*
55.	White Rock Point, north of Mokihinui River, Nelson, M., 1874	VI*a.*
56.	Coal beds, Kokohu River, South Canterbury, Monro, 1869 ...	VI*f.*
57.	Shakespeare Bay and Elevation, near Picton, Marlborough, H., 1865; Ht., 1872; M., 1874	VI*a.*
58.	Point Elizabeth, Cobden, west coast of Nelson, H., 1866; M., 1874	VI*b.*
59.	Darkie Terrace, Cobden, west coast of Nelson, H., 1866; M., 1873	VI*b.*
60.	Poverty Bay, Auckland, H. and M., 1874	VI*a.*
61.	Nummulitic limestone, Greymouth, H. and M., 1873	V*c.*
62.	Railway cutting, Jenkins's Hill, Nelson, M., 1874	VI*d.*
63.	Lake Wakatipu, Otago, H., 1874	VI*e.*
64.	Cobden limestone, Greymouth, Westland, H., 1869; M., 1873 ...	VI*b.*
65.	Bryant's, near Gisborne, Poverty Bay, H. and M., 1874 ...	VI*a.*
66.	Mount Brown, Waipara, Canterbury, H., 1867; M., 1874 ...	V*a.*
67.	Saurian beds, Trelissick section, Broken River, Canterbury, Enys and H., 1872; M., 1874	VI*f.*
68.	Akuaku, east coast of Auckland (Venus beds), H. and M., 1874	VI*a.*
69.	Akuaku, east coast of Auckland (lower beds, Tertiary), H. and M., 1874	V*b.*
70.	Akuaku, east coast of Auckland (upper beds, Tertiary), H and M., 1874	IV*b.*
71.	Grey marls, Weka Pass, Canterbury, H., 1867; M., 1874 ...	VI*a.*
72.	Te Wharoponga, east coast of Auckland, H. and M., 1874 ...	VI*d.*
73.	Limestone, Waipirau Bay, east coast of Auckland, M., 1874 ...	VI*d.*
74.	Weka Pass calcareous greensands, Weka Pass, Canterbury, H., 1867; Ha., 1869; M., 1874	VI*b.*
75.	Kaihiku Gorge, Otago, B., 1869	XI.
76.	Whangaroa, North of Auckland, H. and M., 1866	VI*f.*
77.	Cape Kidnappers, Napier, H., 1866; M., 1875	II*c.*
78.	Cape Kidnappers, Napier, M., 1875	—
79.	Cape Kidnappers, Napier, M., 1875	II*a.*
80.	Scinde Island limestone, Napier, H., 1866	II*a.*
81.	Castlepoint, east coast of Wellington, M., 1875	III*b.*

	Locality.	Formation.
82.	Hakarimata Range, Waikato, Auckland, C. and M., 1875 ...	X*b*.
83.	Waimirima, Napier, M., 1875	VII.
84.	Paonui Point, Pourerere, Napier, M., 1875	VII.
85.	Mouth of Maungakuri River, Napier, M., 1875	VII.
86.	North bank of the Pourerere River, Napier, M., 1875	V*c*.
87.	Nummulitic limestone, Paonui Point, Napier, M., 1875 ...	V*c*.
88.	Roparua and Tuparoa, east coast of Auckland, H. and M., 1874...	VII.
89.	Awanui, east coast of Auckland, M., 1874	VII.
90.	McDonald's Section, Poverty Bay, H. and M., 1874	VI*d*.
91.	Lower part of Shakespeare Cliff, Wanganui, B., 1866	III*a*.
92.	Upper part of Shakespeare Cliff, Wanganui, B., 1866	II*c*.
93.	Taipos, east coast of Wellington, H., 1866	IV*b*.
94.	Taerua River, Wairarapa, Wellington, M., 1875	III*b*.
95.	Makara Valley, Wellington, M., 1876	III*b*. (?)
96.	Raglan, plastic clays, C. and M., 1875	II*b*.
97.	Limestone, five miles north of Raglan, west coast of Auckland, C. and M., 1875	V*b*.
98.	Brown sandstone and flaggy limestone, Raglan, west coast of Auckland, C. and M., 1875	VI*b*.
99.	Leda marls, Raglan, west coast of Auckland, C. and M., 1875 ...	VI*d*.
100.	Leda marls, Miranda Redoubt, Auckland, C. and M., 1875 ...	VI*d*.
101.	Mercer, Waikato River, C. and M., 1875	VI*d*.
102.	Smyth River, Lake Heron, Canterbury, Ha., 1872	VI*e*.
103.	Cave Creek, Mount Somers, Canterbury, Ha., 1872	V*a*.
104.	Fossil Point, Ashburton River, Canterbury, Ha., 1872... ...	V*a*.
105.	St. Peter's Mount, Whangaroa, North of Auckland (plants), H., 1866	III*d*.
106.	Whangaroa, North of Auckland, M., 1875	VII.
107.	Kaeo River, Whangaroa, North of Auckland, M., 1875 ...	VI*e*.
108.	Ruamahunga River, Masterton, B., 1872	III*d*.
109.	Manawatu Gorge (lower end), B., 1872	II*b*.
110.	Culverden, Nelson, Ha., 1869	V*a*.
111.	Whangara, Poverty Bay, east coast of Auckland, H. and M., 1874	VI*e*.
112.	Coralline limestone, Raglan, C. and M., 1875	VI*c*.
113.	Pourerere River, Napier, M., 1875	IV*b*.
114.	Pourerere River, Napier, M., 1875	VII.
115.	Flanks of Castle Range, west of Pourerere, Napier, M., 1875 ...	V*c*.
116.	Waimirima, Napier, Enys, 1874; M., 1875	VI*a*.
117.	Mangapakeha Valley, east coast of Wellington, H., 1866; M., 1875	IV*a*.
118.	Akateo River, east coast of Wellington, H., 1873; Enys, 1874 ...	VII.
119.	Akateo River, east coast of Wellington, H., 1873	I*c*.
120.	Mariatotara River, Napier (Young Tertiary), M., 1875 ...	II*b*.
121.	Korakonui, east coast of Wellington, H., 1866	IV*b*.
122.	Waimirima, coast of Napier (Scinde Island beds), M., 1875 ...	II*b*.
123.	Kupakupa Coal Mine, Waikato, Auckland (plants), C. and M., 1875	VI*g*.
124.	Black marls, Mount Rochfort, M., 1874	VI*e*.
125.	Fox River, Brighton, west coast of Nelson, M., 1874	IV*b*.
126.	Awatere River, Marlborough, B., 1867	III*d*.
127.	Awatere Point, Awanui, east coast of Auckland, M., 1874 ...	VII.
128.	Mount Arthur, Nelson, H., 1867; M., 1879	XIV*a*.
129.	Rainy Creek, Reefton (Devonian), H. and M., 1874	XIII*a*.
130.	Lankie's Gully, Reefton, H. and M., 1874	XIII*a*.
131.	Lower Kaihiku Gorge, Otago, M., 1873	XI.
132.	Wyndham River, Otago, B., 1866	IX*a*.
133.	Nugget Point, Otago, H., 1869; M., 1873	X*a*.
134.	Wiltshire Beach, Molyneux Bay, Otago, M., 1873	XI*a*.
135.	Upper Purerua Gorge, M., 1873	X*c*.
136.	Mount Potts, Rangitata River, Canterbury, Ha., 1872... ...	XI*a*.
137.	Benmore, Hokanui District, Southland, H., 1869	X*a*, *b*.
138.	Moonlight Range, Southland, Ht., 1872	X*b*.
139.	Richmond Hill, Nelson, H., 1866	X*b*.

	Locality.	Formation.
140.	Wairoa Gorge, Nelson, H., 1866	X*b*.
141.	Wairoa Gorge, Nelson, M., 1874	X*b*.
142.	Aniseed Valley, Nelson (Monotis beds), H., 1866	X*b*.
143.	Dun Mountain, Nelson, H., 1866; M., 1878	XII*a*.
144.	Morley Creek, Southland, H., 1869	IX*a*.
145.	Otapiri Creek, Southland, H, 1869...	IX*a*.
146.	Tautuku, Otago, H., 1869	IX*a*.
147.	Between Nugget Point and Cannibal Bay, Otago, M., 1873 ...	IX*a*.
148.	Mainland, opposite Bloody Jack's Island, Otago, M., 1873 ...	IX*a*.
149.	McKay's Creek, Middle Waipara, Canterbury, M., 1874 ...	VI*f*.
150.	Grey marls, Heathstock, Upper Waipara, Canterbury, M., 1874	VI*a*.
151.	Okuku Range, West of Mount Grey, Canterbury, M., 1874 ...	X*b*.
152.	Weka Creek, Weka Pass, Canterbury, M., 1874	VI*f*.
153.	Callaghan's Hill, Westland, C. and M., 1875...	III*d*.
154.	Kanieri River, Westland, C. and M., 1875	IV*b*.
155.	Ross, Westland, C. and M., 1875	III*c*.
156.	Abbey Rocks, Paringa District, Westland, C. and M., 1876 ...	VI*e*.
157.	Kaikoura Peninsula, Marlborough, M., 1876	VI*f*.
158.	Amuri Bluff Hill, M., 1876	II*a*.
159.	Mount Grey Downs, Canterbury, M., 1874	IV*b*.
160.	Grey Stream, Mount Grey, Canterbury, M., 1874	IV*b*.
161.	Nugget Point, Otago, B., 1866	X*a*.
162.	Weka Pass Stone, Kokohu River, South Canterbury, M., 1876 ...	VI*b*.
163.	Greensands, overlying coal, Kokohu River, S. Canterbury, M., 1876	VI*e*.
164.	Coal beds, Kokohu River, South Canterbury, M., 1876 ...	VI*f*.
165.	White Rock River, Upper Pareora River, Canterbury, M., 1876	IV*b*.
166.	Lower Gorge, Pareora River, Canterbury, M., 1876	IV*b*.
167.	Lower Gorge, Pareora River (coal beds), M., 1876; Enys, 1879	VI*f*.
168.	Otepopo River, Oamaru, Otago, M., 1876	VI*e*.
169.	Kakanui limestone, Kakanui, Otago, M., 1876	V*b*.
170.	Awamoa Creek, Oamaru, Otago, M., 1876	IV*b*.
171.	Cape Wanbrow to breakwater, Oamaru, Otago, M., 1876 ...	VI*e*.
172.	Hutchison's Quarry, Oamaru, M., 1876	V*b*.
173.	Limekiln Gully, Oamaru, Otago, M., 1876	V*b*.
174.	Devil's Bridge, Oamaru Creek, Otago, M., 1876	V*b*.
175.	One mile south of Devil's Bridge, Oamaru Creek, Oamaru, M., 1876	IV*b*.
176.	Black Point, Waitaki River, Otago, M., 1876	VI*e*, *f*.
177.	Macrewhenua gold workings, Otago, M., 1876	VI*f*.
178.	Phorus beds, Maraewhenua, Waitaki, Otago, M., 1876 ...	VI*a*.
179.	Macrewhenua limestone, Waitaki, Otago, M., 1876	VI*b*.
180.	Dorset's, Forty-Mile Bush, Wellington, M., 1877	III*b*.
181.	Manawatu Gorge, Wellington (upper end), M., 1877	III*b*.
182.	Manawatu Gorge, Wellington (lower end), M., 1877	II*b*.
183.	Norsewood, Seventy-Mile Bush, Napier, M., 1877	II*b*.
184.	Porangahau Creek, Ruataniwha Plains, Napier, M., 1877 ...	II*e*.
185.	Johnston's, Ruataniwha Plains, Napier (shell limestone), M., 1877	II*c*.
186.	Waipawa River, Napier, M., 1877	VI*d*.
187.	Stokes's Run, Te Aute Hills, Napier (shell limestone), M., 1877...	III*b*.
188.	Kereru, inland from Napier (Rotella beds), M., 1877	II*c*.
189.	Kereru, inland from Napier (limestone), M., 1877	III*b*.
190.	Kereru, inland from Napier (lower beds), M., 1877	III*b*.
191.	Shrimpton's, Ngarurora River, Napier (upper), M., 1877 ...	II*a*.
192.	Shrimpton's, Ngarurora River, Napier (middle), M., 1877 ...	II*a*.
193.	Shrimpton's, Ngarurora River, Napier (lower), M., 1877 ...	II*b*.
194.	Scinde Island, Napier, M., 1877	II*c*.
195.	Plant beds, Eighty-eight Valley, M., 1878	IX*a*.
196.	Trigonia beds, Eighty-eight Valley, M., 1878...	IX*a*.
197.	Sporiferina beds, Eighty-eight Valley, M., 1878	IX*a*.
198.	Hokianga, Auckland (Tertiary beds), H., 1874	IV*b*.
199.	Morrison's, north of Auckland (coal beds), H., 1874	VI*e*, *f*.
200.	Evans's Bay, Wellington Harbour, M., 1876...	I*c*.

	Locality.	Formation.
201.	Taipos, east coast of Wellington, M., 1875	IV*b*.
202.	Turanganui, Poverty Bay, Gisborne (No. 1), H. and M., 1874 ...	I*c*.
203.	Turanganui, Poverty Bay, hill east of river (No. 2), H. and M., 1874	II*a*.
204.	Turanganui, Poverty Bay, McDonald's section (No. 3), H. and M., 1874	II*b*.
205.	Durie's Hill, Wanganui, Kirk, 1875	II*b*.
206.	Shakespeare Cliff, Wanganui (upper part), Kirk, 1875 ...	II*c*.
207.	Railway cutting, ten miles from Wanganui, Kirk, 1875 ...	II*a*.
208.	Lower part of Shakespeare Cliff, Wanganui, Kirk, 1875 ...	III*a*.
209.	Waitotara, west coast of Wellington, H., 1870	III*d*.
210.	Mount Reilly, New River District, Westland, M., 1874 ...	III*c*.
211.	New River, Westland (Tertiary), H., 1869	III*d*.
212.	Ormond, Poverty Bay, M., 1874	II*a*.
213.	Awamoa, Oamaru, Otago, Traill, 1865	IV*b*.
214.	Hampden, Otago, Traill, 1865	IV*b*.
215.	Sherry River, Nelson, H., 1867	VI*e*.
216.	Mount Caverhill, Nelson, Ha., 1869	IV*b*.
217.	Cape Kidnappers and Te Aute hills, H., 1867	II*a*. to III*b*.
218.	Motunau, Canterbury, B., 1867	IV*b*.
219.	Motunau, Canterbury, B., 1867	II*a*.
220.	Petane, Hawke's Bay, Napier (shell limestone), C., 1876 ...	II*a*.
221.	Petane, Hawke's Bay, Napier (sandy clays), C., 1876	II*b*.
222.	Watchman's Island, Napier Harbour, Williams, 1878... ...	II*c*.
223.	North side of Tokomarua Bay, M., 1874	IV*b*.
224.	Kakanui River, Oamaru, Otago, M., 1876	VI*e*.
225.	Gilligan's, Westland, H., 1869	III*d*.
226.	Upper Trelissick, Enys and H., 1872	IV*b*.
227.	Kanieri, Westland, H., 1869	IV*b*.
228.	Lower gorge of the Waipara, Canterbury, H., 1867	IV*b*.
229.	Manawatu Gorge, B., 1874	II*b*.
230.	Kaipuki Cliffs, Nelson, H., 1867	V*a*.
231.	McLean's, Ngaruroro River, Napier, H., 1871	II*b*.
232.	Hurunui Mound, Nelson, Ha., 1869	IV*b*.
233.	Waikare, Canterbury, H., 1872	IV*b*.
234.	Lake Lyndon, West Coast Road, Canterbury, H., 1872 ...	IV*b*.
235.	Plant beds, road cutting, Thomas River, Trelissick Basin, M., 1874	III*d*.
236.	Pareora beds, Thomas and Porter Rivers, Trelissick Basin, M., 1879	IV*b*.
237.	Upper part of Mount Brown limestone, Trelissick Basin, M., 1879	V*a*.
238.	Mount Brown limestone, Coleridge Creek, Trelissick Basin, Enys, 1866, 1879	V*a*.
239.	Fan-coral bed, Porter and Thomas Rivers, Trelissick Basin, M., 1879	V*d*.
240.	Below Weka Pass stone, Porter River, Trelissick Basin, M., 1879	VI*b*.
241.	Tufaceous greensands, Whitewater Creek, Trelissick Basin, M., 1879	VI*e*.
242.	Weka Pass stone, Trelissick Basin, Enys, 1866, 1879	VI*b*.
243.	Fan-coral bed, Trelissick Basin, Enys, 1866, 1879	V*d*.
244.	Pareora beds, Trelissick Basin, Enys, 1866, 1879	IV*b*.
245.	Castle Rock, Southland, M., 1878	IV*b*.
246.	Cape Rodney, Auckland, H., 1866; C., 1879	IV*b*.
247.	Forest Hill Range, Southland, M., 1878	V*a*.
248.	Waitaki River, Otago, H., 1865	V*b*, *d*.
249.	Duncan's, east coast of Auckland, H. and M., 1874	IV*b*.
250.	Aohanga Falls, Akateo River, east coast of Wellington, H., 1873	IV*b*.
251.	Wharekauri, Traill, 1874	V*d*.
252.	Otakaika, Traill, 1874	V*c*.
253.	Pakeuri, Traill, 1874	V*c*.
254.	Awamoa, Traill, 1874	IV*b*.
255.	Cape Hills, Oamaru, Trail, 1874	V*b*.

	Locality.	Formation.
256.	Grey marls, Otapiri Creek, Southland, M., 1878	VI*a*.
257.	Kawau Island, H., 1866	IV*b*.
258.	Waimea Plains, Southland (limestone), H., 1869	V*a*.
259.	Parakino and Upper Wanganui Rivers, Cr., 1862	III*d*., IV*b*.
260.	Hautapu Falls, Rangitikei River, H., 1870	III*d*.
261.	Tataka River, Nelson, H., 1868	V*a*.
262.	Orepuki, Southland, H., 1869	V*b*.
263.	Hicks Bay, Auckland, H., 1874	IV*b*.
264.	Flaxbourne, Marlborough, M., 1876	VI*f*.
265.	Flaxbourne, Marlborough, M., 1876	III*d*.
266.	Point Elizabeth, Cobden, Nelson, H.	VI*b*.
267.	Waikato Heads, C., 1876	VIII*b*.
268.	Aotea sandstone, between Raglan and Kupakupa, Waikato, C., 1876	VI*b*.
269.	Limestone, between Raglan and Kupakupa, Waikato, C., 1876 ...	VI*b*.
270.	Parua Bay, Whangarei, Auckland, C., 1876	VI*f*.
271.	Walton's Coal Mine, Whangarei, Auckland, H., 1865	VI*e*.
272.	Waikawau Creek, Waikato, Auckland, C., 1876	VI*a*.
273.	Wangape Lake, Ht., 1866	VI*d*.
274.	One mile below Lyell, Buller River, Nelson, H., 1869	VI*f*.
275.	Grey marls, Weka Pass stone, and greensand conglomerate, east wing Amuri Bluff, M., 1876	VI*a*, *b*.
276.	Kawhia Harbour, west coast of Auckland, H., 1866	VIII*b*.
277.	Bobbie's Creek, Waipara District, Canterbury, H., 1867 ...	VI*f*.
278.	Source of the Mokihinui River, Nelson, H., 1867	VI*e*.
279.	Whangarei and Kawakawa, Auckland, H., 1866	VI*f*.
280.	Measley Beach, Otago, H., 1869	VI*f*, *e*.
281.	Between Ngakawau and Mokihinui Rivers, Buller District, H., 1871	VI*f*.
282.	Whangarei, Auckland, C., 1867	VI*f*.
283, 275.	Tiger Hill, Whangarei, Auckland, H., 1867	VI*f*.
284.	Morrison's District, North of Auckland, H., 1874	VI*e*.
285.	Grey marls, Hawke's Bay, northern district, C., 1876	VI*a*.
286.	Cobden limestone, Marsden Road, Greymouth, M., 1873 ...	VI*b*.
287.	Tokomarua Bay, east coast of Auckland, M., 1874	VI*a*.
288.	Waireka Valley, Oamaru, Otago, M., 1876	VI*d*.
289.	Port Waikato, Auckland, C., 1876	VIII*b*.
290.	Marsden, New River District, Westland, M., 1873	V*c*.
291.	Maitai formation, Westland, M., 1875	XII*a*.
292.	Great Barrier Island, Ht., 1866	XIV*a*.
293.	Hapuka River, Looker-on Mountains, Marlborough, M., 1876 ...	VI*e*, *f*.
294.	Kaikoura Peninsula, Marlborough, M., 1876	VI*e*.
295.	Saurian beds, Heathstock Junction, Upper Waipara, M., 1874 ...	VI*f*.
296.	Fossil Point, Cape Farewell, Nelson, H., 1868	V*a*.
297.	Orakei Bay, Auckland, H., 1866	VI*a*.
298.	Surveyors' Gully, Malvern Hills, Canterbury	VI*f*.
299.	Breakwater, Oamaru, Otago, M., 1876	I*c*.
300.		
301.	Coral beds, Waikawau Creek, Waikato, Auckland, C., 1876 ...	VI*a*.
302.	Tata Island, Nelson, H., 1868	V*a*.
303.	Clifton, Nelson, H., 1868	
304.	Culverden, Nelson, M., 1874	V*a*.
305.	Black Birch Creek, Nelson, Ha., 1869	V*a*.
306.	Marble Point, Waiau-ua River, Nelson, Ha., 1869	V*a*.
307.	Grey marls, Cuff's Oil Springs, Poverty Bay, Auckland, H. and M., 1874	VI*a*.
308.	Oamaru, Otago, H., 1876	V*b*.
309.	Caversham, Dunedin, Otago, M., 1876	VI*a*.
310.	Interbedded with volcanic rocks, Oamaru Creek, Oamaru, M., 1876	V*c*.
311.	Curiosity Shop, Rakaia River, Canterbury, M., 1879	V*a*.
312.	South-west side of Oamaru Cape, Otago, M., 1876	V*b*.
313.	Dean's, Waipara River, Canterbury, H., 1872	V*a*.

	Locality.	Formation.
314.	Cape Campbell, M., 1876	VII.
315.		
316.		
317.	Te Aro, Wellington	I*c*.
318.	Wairoa Gorge (Tertiary beds), M., 1878	IV*b*.
319.	Port Hills, Nelson, M., 1874	IV*b*.
320.	Shag Point, Otago (shells), H., 1865	VI*f*.
321.	Waiau-ua River, Marlborough, B., 1867	VI*d*.
322.	Below Flaggy Limestone, Waikato Heads, C., 1877	VI*c*.
323.	Cardita beds, Waikawau Creek, Waikato, C., 1877	VI*a*.
324.	Marls, Baton River, Nelson, H., 1868	VI*e*.
325.	Red Cliff, Rakaia River, Canterbury, M., 1874	III*d*.
326.	Red Cliff, Rakaia River, Canterbury, M., 1874	V. and VI.
327.	Awamoa Bridge, Oamaru, South Road, M., 1876	V*b*.
328.	Cook's Cove, Tolago Bay, east coast of Auckland, M., 1874 ...	IV*b*.
329.	Pomahaka River, Otago, H., 1869	IV*b*.
330.	Ngaruroro Gorge, Napier, M., 1877	III*c*.
331.	Dunedin Harbour	I*c*.
332.	Inoceramus beds, Makarewa, Hokanui Hills, Southland, C. and M., 1877	VIII*b*.
333.	Avicula beds, Flag Hill, Hokanui District, Southland, C. and M., 1877	VIII*b*.
334.	Astarte beds, lower end of Otapiri Gorge, Southland, C. and M., 1877	VIII*b*.
335.	Astarte beds, road cutting, north side of Peel Hill, C. and M., 1877	VIII*b*.
336.	Astarte beds, top of Flag Hill, C. and M., 1877	VIII*b*.
337.	Highest Spirifer bed, Conical Hill, Otapiri Gorge, M., 1878 ...	VIII*c*.
338.	Highest Spirifer bed, table-land above Tree Bluff, Otapiri Gorge, M., 1878	VIII*c*.
339.	Highest Spirifer bed, north face of Flag Hill, M., 1878 ...	VIII*c*.
340.	Highest Spirifer bed, Upper Lora, behind Taylor's station, M., 1878	VIII*c*.
341.	Lower Belemnite beds, north face of Flag Hill, M., 1878 ...	VIII*c*.
342.	Little Spirifer grit, north face of Flag Hill, M., 1878	VIII*c*.
343.	Upper Plagiostoma bed, west face of Flag Hill, M., 1878 ...	IX*a*.
344.	Upper Plagiostoma bed, north face of Flag Hill, M., 1878 ...	IX*a*.
345.	Upper Plagiostoma bed, west face of Bastion Hill, M., 1878 ...	IX*a*.
346.	Saddle between Taylor's Creek and Lora Station, M., 1878 ...	IX*a*.
347.	Upper Ammonite bed, west face of Flag Hill, M., 1878 ...	IX*a*.
348.	Higher part of Lower Plagiostoma bed, M., 1878	IX*a*.
349.	Lower part of Lower Plagiostoma bed, M., 1878	IX*a*.
350.	Between lower part of Lower Plagiostoma bed and Middle Ammonite bed, M., 1878	IX*a*.
351.	Overlying Upper Cannon-ball sandstone, Flag Hill to North Peak section, M., 1878	IX*a*.
352.	Middle Ammonite bed, Otapiri Creek, M., 1878	IX*a*.
353.	Middle Ammonite bed, slopes of Bare Hill, behind Taylor's Station, Lora Stream, M., 1878	IX*a*.
354.	Lower Ammonite bed, Taylor's Creek, junction of south branch; Flag Hill to North Peak Section, M., 1878...	IX*a*.
355.	Lower Ammonite bed, junction of Taylor's Creek and Otapiri, M., 1878	IX*a*.
356.	Below Lower Ammonite bed, junction of Taylor's Creek and Otapiri, M., 1878	IX*a*.
357.	Lower part of Lower Ammonite bed, Flag Hill to North Peak Section, M., 1878	IX*a*.
358.	Lower part of Lower Ammonite bed, Taylor's Creek, below the woolshed, M., 1878	IX*a*.
359.	Lower Cannon-ball sandstone, Taylor's Creek, M., 1878 ...	X*a*.
360.	Below Lower Cannon-ball sandstone, Taylor's Creek, M., 1878 ...	X*a*.
361.	North-west branch of Taylor's Creek, above Trigonia beds, M., 1878	X*a*.
362.	Taylor's Crossing, Otapiri Creek, M., 1878	X*a*.

	Locality.	Formation.
363.	Benmore Yards, M., 1878...	X*a*.
364.	Trigonia beds, north-west branch of Taylor's Creek, M., 1878 ...	X*a*.
365.	Blue sandstone, north-west branch of Taylor's Creek, M., 1878 ...	X*a*.
366.	Blue sandstone and chert, main branch of Taylor's Creek, M., 1878	X*a*.
367.	Banks of the Otapiri Creek, one mile above Taylor's Crossing, M., 1878	X*a*.
368.	Trigonia beds, slopes of the southern peak of Benmore Range, M., 1878	X*a*.
369.	Benmore sandstone, south peak, Benmore Range, M., 1878 ...	X*a*.
370.	Lowest bed of the Otapiri series, north-west branch of Taylor's Creek, M., 1878	X*a*.
371.	Benmore sandstone, Benmore railway cutting, M., 1878 ...	X*a*.
372.	Oreti railway cutting, M., 1878	X*a*.
373.	Monotis sandstone, Oreti Railway-station, M., 1878	X*b*.
374.	Monotis sandstone, southern peak of Benmore Range, M., 1878...	X*b*.
375.	Monotis sandstone, north-west branch of Taylor's Creek, M., 1878	X*b*.
376.	Railway cutting, north of Oreti Railway-station, M., 1878 ...	X*b*.
377.	Ash beds, North Peak section, M., 1878	XI*a*.
378.	Inoceramus beds, overlying Big Conglomerate, Oreti River, M., 1878	XI*a*.
379.	Spirigera beds, overlying Big Conglomerate, Oreti River, M., 1878	XI*a*.
380.	Spirifer and Crinoid beds, near Cowan's Railway-station, M., 1878	XI*c*.
381.	Spirifer and Crinoid beds, North Peak, M., 1878	XI*c*.
382.	Wairoa Gorge, M., 1875	X*b*.
383.	Mytilus problematicus bed, west side of Mount Wellington, Wairoa Gorge, M., 1878-79	X*b*.
384.	Halobia bed, east side of Mount Wellington, Wairoa Gorge, M., 1878-79	X*b*.
385.	Nautilus bed, east side of Mount Wellington, Wairoa Gorge, M., 1878-79	X*a*.
386.	Monotis sandstone, eastern slopes of Mount Wellington, Wairoa Gorge, M., 1878-79	X*b*.
387.	Mytilus problematicus beds, east slopes of Mount Wellington, Wairoa Gorge, M., 1878-79	X*b*.
388.	Limestone, Martin's saw-mill, upper end of Wairoa Gorge, M., 1878-79	XII*a*.
389.	Limestone, upper end of Wairoa Gorge, M., 1878-79	XII*a*.
390.	Spirifer beds, upper part of Spring Grove Creek, Wairoa Gorge, M., 1878	X*b*.
391.	Monotis sandstone, Spring Grove Creek, Wairoa Gorge, M., 1878	X*b*.
392.	Top of the range head of Spring Grove Creek, Wairoa Gorge, M., 1878	X*b*.
393.	Lowest beds, Sellen's section, West Wairoa Gorge, M., 1878 ...	X*b*.
394.	Spirigera beds, Sellen's section, Wairoa Gorge, M., 1878 ...	X*b*.
395.	Mytilus problematicus beds, Sellen's section, Wairoa Gorge, M., 1878-79	X*b*.
396.	Great limestone, Sellen's, Wairoa Gorge, M., 1868-69... ...	XII*a*.
397.	Productus limestone, Sellen's, Wairoa Gorge, M., 1868-69 ...	XII*a*.
398.	Fossiliferous slates, Little Ben, Wairoa River, M., 1868 ...	XII*a*.
399.	Fossiliferous slates, Dun Mountain tramway, M., 1868 ...	XII*a*.
400.	Upper Gorge of the Maitai River, M., 1878	XII*a*.
401.	Mount Potts Spirifer beds, M., 1877	XI*a*.
402.	Mount Potts Glossopteris beds, M., 1877	XI*a*.
403.	Seaward Downs	
404.	Taylor's Creek (plants), M., 1868	IX*a*.
405.	Clent Hills (plants), Ha., 1872	VIII*b*.
406.	Mataura (plants), B., 1863; M., 1879	VIII*a*.
407.	Otapiri (plants), H., 1869...	VIII.
408.	Owake Creek (plants), H., 1865	VIII*b*.
409.	Waikato Heads (plants), H., 1866	VIII.
410.	Pakawhau Coal Field (plants), H., 1868	VI*g*.
411.	Buller Coal Field, H., 1869	VII.

	Locality.	Formation.
412.	Grey Coal Field, H., 1869	VII.
413.	Wangapeka, H., 1868	VII.
414.	Shag Point, B., 1869	VII. (?)
415.	Mount Hamilton, H., 1869	
416.	Whangarei (coal), H., 1866	VI*g*.
417.	Kawakawa, H., 1866	VI*g*.
418.	Whangaroa, H., 1866	III*d*.
419.	Cromwell	
420.		
421.	Landslip Hills (plants), H., 1869	
421.	Mongonui (plants), H., 1866	
422.	Knight's Hut, Malvern, H., 1869	VIII.
423.	Surveyors' Gully, Malvern, Ha., 1869	VI*g*.
424.	Jebson's Mine, Malvern, H., 1869	VI*g*.
425.	Trelissick (plants), H., 1872	VI*g*.
426.	Waikawa (plants), H., 1865	VIII*a*.
427.	Morley Creek and Linton, H., 1869	VI*g*.
428.	Abbey Rocks, C., 1875	VI.
429.	Mount Torlesse Annelid bed, H., 1869	XII*a*.
430.	Karori sandstone, Wellington, H., 1866	XII*a*.
431.	Graptolite slates, Collingwood	XIV*b*.
432.	Monotis beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
433.	Halobia beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
434.	Mytilus beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
435.	Psioidea beds, Eighty-eight Valley, Nelson, M., 1878	X*b*.
436.	Kaihiku beds, Eighty-eight Valley, Nelson, M., 1878	XI*a*.
437.	Nautilus beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*a*.
438.	Monotis beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*b*.
439.	Mytilus beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*b*.
440.	Psioidea beds, Mount Wellington, Wairoa Gorge, Nelson, M., 1878	X*b*.
441.	Limestone, Martin's Mill, Wairoa Gorge, Nelson, M., 1878 ...	XII*a*.
442.	Mytilus beds, north side of Wairoa Gorge, Nelson, M., 1878 ...	X*b*.
443.	Psioidea beds, north side of Wairoa Gorge, Nelson, M., 1878 ...	X*b*.
444.	Graham River, Motueka Valley, Nelson, M., 1879	XIV*a*.
445.	Dart River, Wangapeka, Nelson, M., 1879	XIV*a*.
446.	Rolling River, Wangapeka, Nelson, M., 1879	XIV*a*.
447.	Rolling River, Wangapeka, Nelson, M., 1879	XIV*a*.
448.	Source of Clark River, Wangapeka, Nelson, M., 1879	XIV*a*.
449.	Lower beds, Trelissick Basin, Enys, 1880	VI*e*.
450.	Cape Rodney, Auckland, C., 1880	IV*b*.
451.	Komiti Point, Kaipara, Auckland, C., 1880	VI*a*.
452.	Mataura River, west bank, below falls, M., 1879	IV.
453.	Mohaka River, Auckland, H, 1871	
454.	Kawakawa, Auckland, C., 1879	VI*e.f*.
455.	Monotis beds, Okuku Range, Canterbury, M., 1879	X*b*.
456.	Cretaceo-Tertiary beds, Lake Wakatipu, Otago, M., 1880 ...	VI*e*.
457.	Pareora beds, Lake Wakatipu, Otago, M., 1880	IV*b*.
458.	Lower part of Pareora River, Canterbury, Enys, 1879... ...	IV*b*.
459.	Mouth of Wyndham River, Otago, M., 1879	IX*a*.
460.	Otapiri beds, Wharfdale, Ashley River, Canterbury, M., 1879 ...	X*a*.
461.	One mile below Mataura Falls, Otago, M., 1879	IX*a*.
462.	Baton River, near junction of the Clark River, Nelson, M., 1879	VI*e*.
463.	Near mouth of the Clark River, Baton River, Nelson, M., 1879 ...	VI*d*.
464.	Limestone Island, Whangarei, Auckland, C., 1879	V.
465.	Opposite Captain Colbeck's, Kaipara, Auckland, C., 1880 ...	V.
466.	Clark's Cutting, Whakahara, Auckland, C., 1879	VI*a*.
467.	Tangitiroria (Wilson's), Wairoa River, Auckland, C., 1879 ...	VII.
468.	Pareora beds, Wairoa Gorge, Nelson, M., 1878	IV*b*.
469.	Ostrea beds, south of Selwyn River, Malvern Hills, Canterbury, M., 1879	VI*f*.
470.	East bank of Mataura, one and a half miles below bridge, M., 1879	VIII*c*.

	Locality.	Formation.
471.	East bank of Mataura River, one mile below the bridge, M., 1879	VIIIc.
472.	Popotuna Gorge, Otago (east end), M., 1879...	XIa.
473.	Sellen's, Eighty-eight Valley, M., 1879	XIIa.
474.	Limestone Bluff, Ashburton River, Canterbury, C., 1876 ...	Va.
475.	Mount Harris, Waihoa River, Canterbury, M., 1880	IVb.
476.	Kekenodon beds, Waitaki River, Otago, M., 1880	Vd.
477.	Otakaika limestone, Station Peak, Waitaki, Otago, M., 1880 ...	Vc.
478.	Otakaika limestone, Wharekauri, Waitaki, Otago, M., 1880 ...	Vc.
479.	Marly greensands, Waihoa River, Canterbury, M., 1880 ...	VIe.
480.	Island sandstone, Waihoa River, Canterbury, M., 1880 ...	VIf.
481.	Otakaika limestone, Otakaika, M., 1880	Vc.
482.	Waihoa limestone, Waihoa River, Canterbury, M., 1880 ...	VIb.
483.	Hutchison's Quarry beds, Wharekauri, Waitaki Valley, Otago, M., 1880	Vb.
484.	Maerewhenua limestone, Pigeon Rock, Waitaki Valley, Otago, M., 1880	VIb.
485.	Grey marls, Waihoa River, Canterbury, M., 1880	VIa.
486.	Wharekauri greensand, Wharekauri, Waitaki Valley, Otago, M., 1880	VIe.

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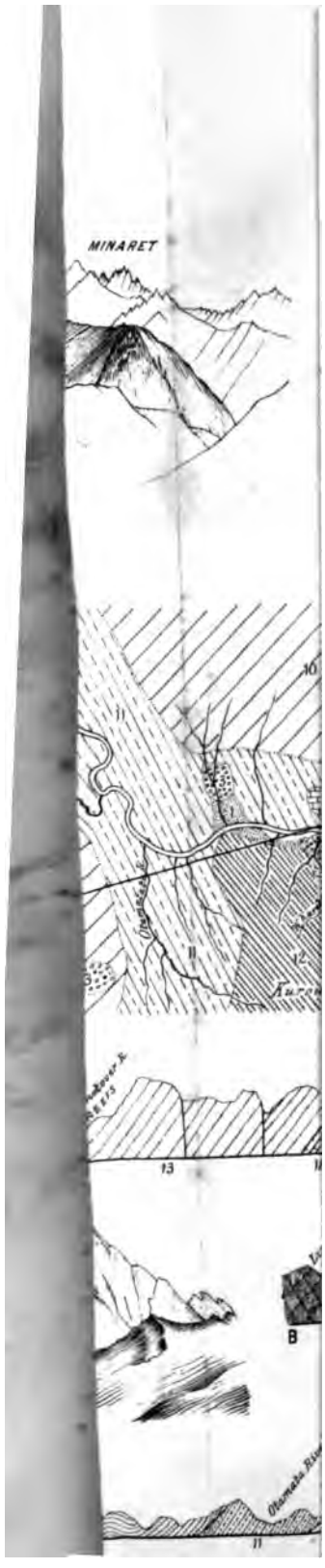
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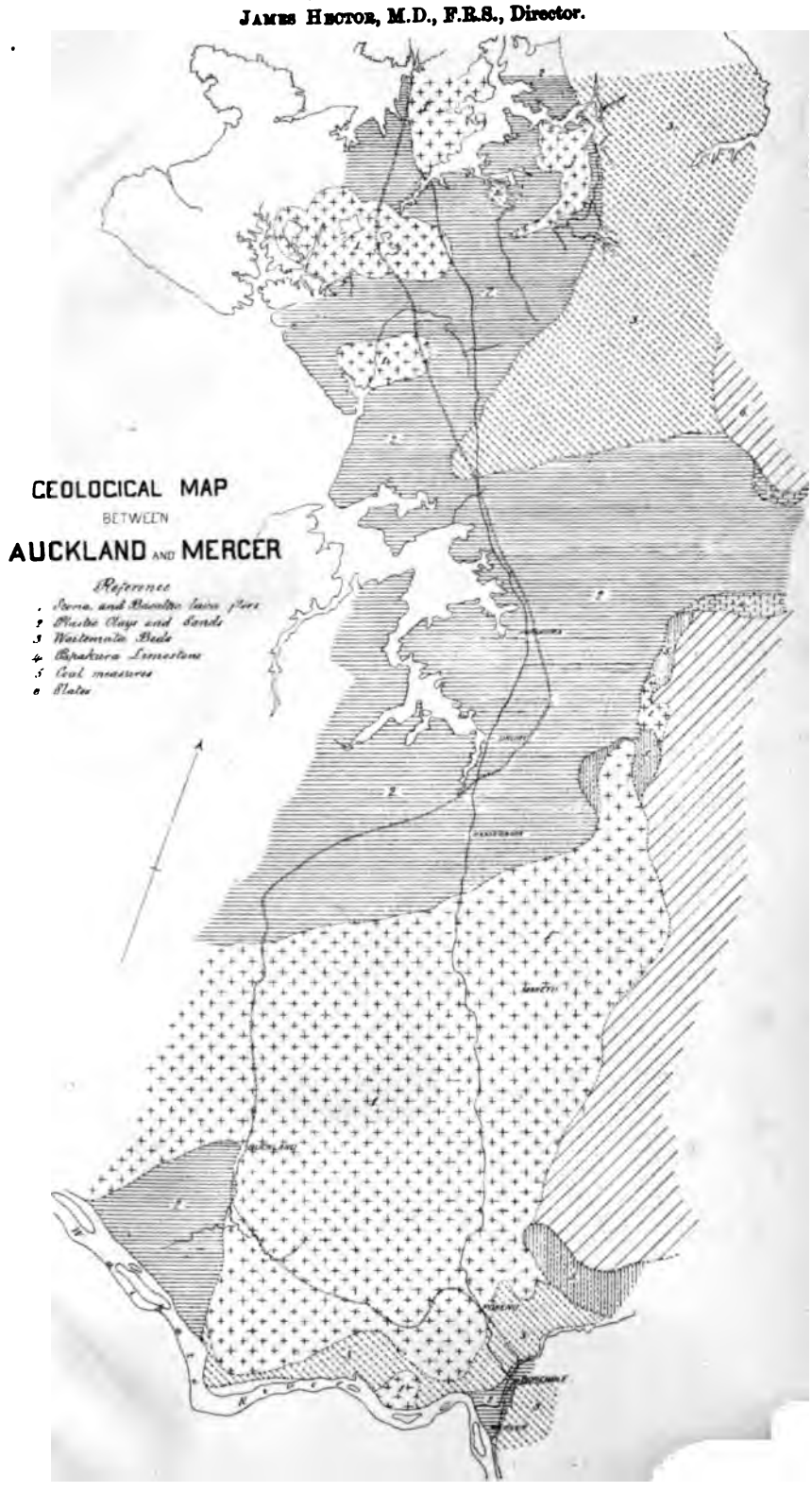

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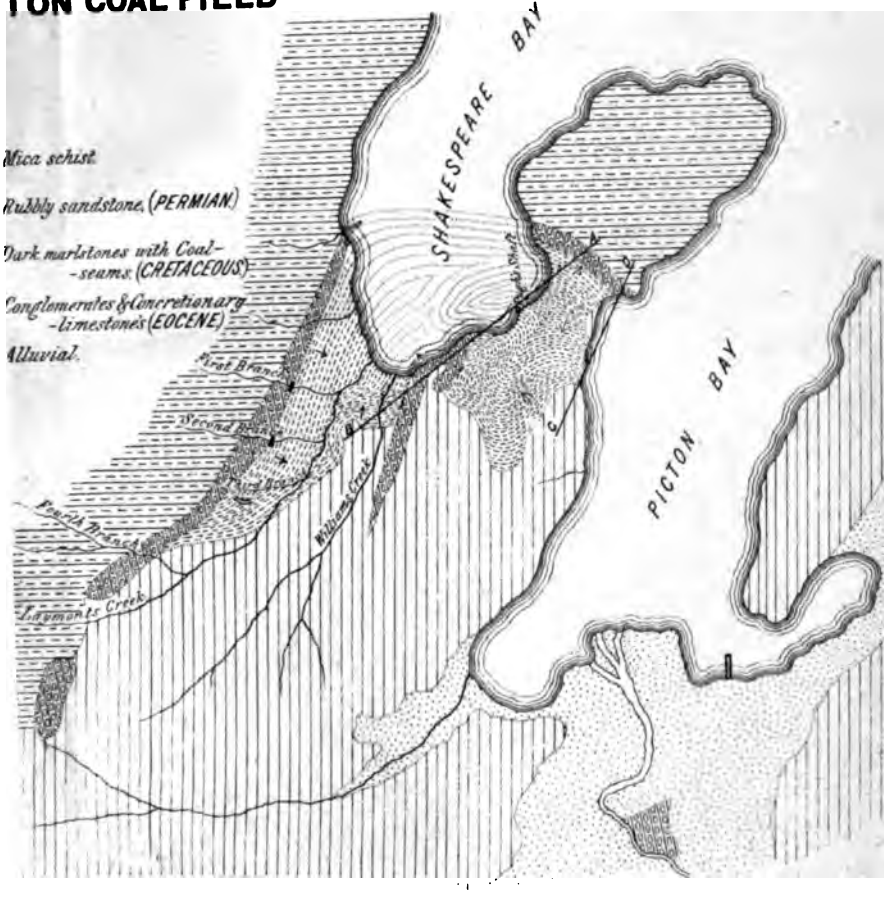

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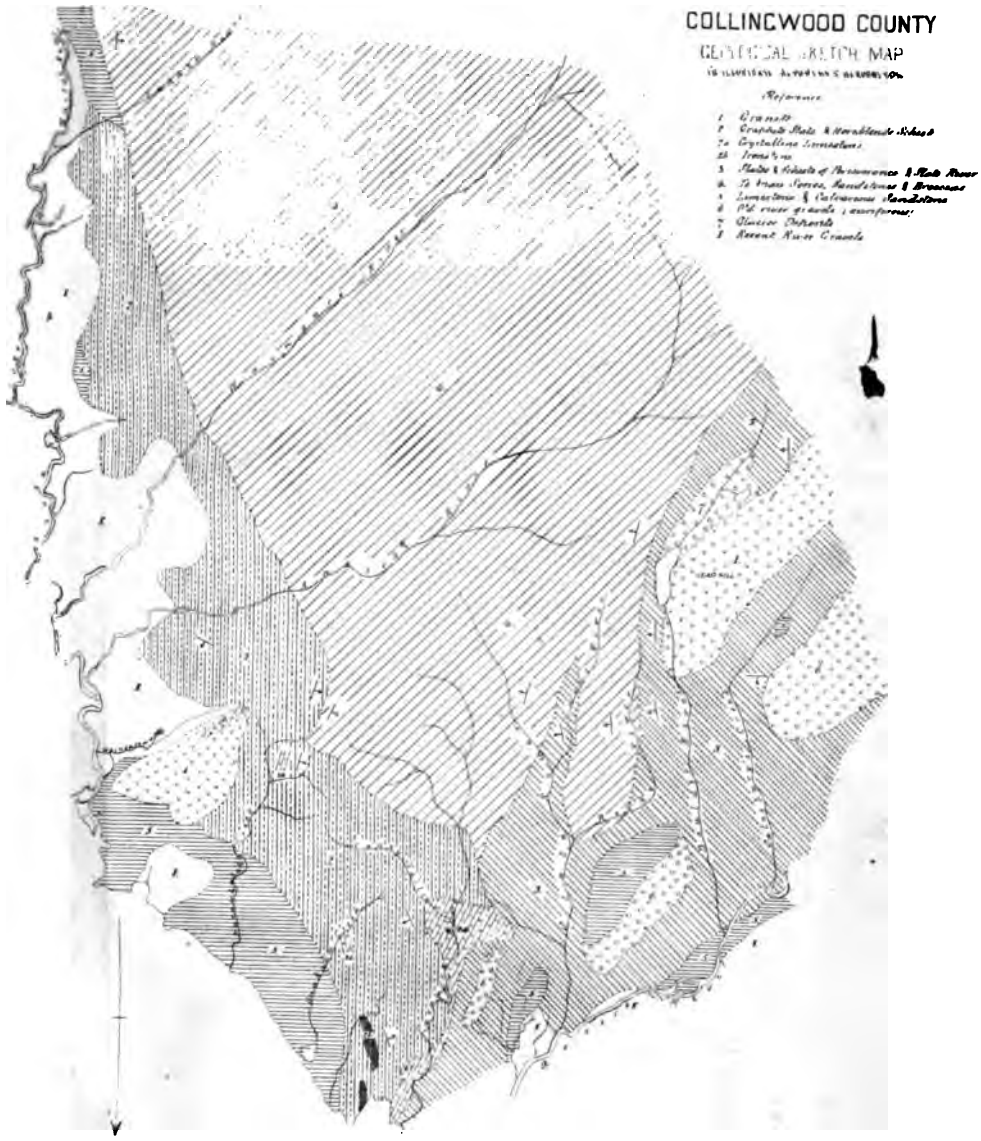

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